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# THE CHERNOBYL ACCIDENT

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## HEARING

BEFORE THE

## COMMITTEE ON
## ENERGY AND NATURAL RESOURCES
## UNITED STATES SENATE

NINETY-NINTH CONGRESS

SECOND SESSION

ON THE

CHERNOBYL ACCIDENT AND IMPLICATIONS FOR THE DOMESTIC NUCLEAR INDUSTRY

JUNE 19, 1986

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# THE CHERNOBYL ACCIDENT

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### THURSDAY, JUNE 19, 1986

U.S. SENATE,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
*Washington, DC.*

The committee met, pursuant to notice, at 9:30 a.m., in room SD-366, Dirksen Senate Office Building, Hon. James A. McClure (chairman) presiding.

Present: Senators McClure, Domenici, Wallop, Warner, Murkowski, Nickles, Hecht, Bumpers, Metzenbaum, and Melcher.

Also present: K.P. Lau and Marilyn Meigs, professional staff members; and Benjamin S. Cooper, professional staff member for the minority.

## OPENING STATEMENT OF HON. JAMES A. McCLURE, A U.S. SENATOR FROM THE STATE OF IDAHO

The CHAIRMAN. The committee will come to order.

The April 26 accident at the Chernobyl nuclear reactor in the Soviet Union has stimulated a lot of interest in a myriad of issues related to the continued use of nuclear powerplants in this country and abroad.

From members of this committee, we have had expressions of concern about the immediate and long-term health effects of the Chernobyl accident, the safety of our U.S. commercial and defense reactors, the need for licensing reform, and the accident's overall impact on the world energy supplies.

From an international perspective, we have already seen an increased interest in expanding the role of the International Atomic Energy Agency with respect to nuclear safety issues, including the negotiation of international agreements for early notification about nuclear incidents, and coordinating emergency response and assistance in the event of a nuclear accident that releases radioactivity into neighboring countries.

I wish to commend the IAEA for the responsiveness it has already shown in the wake of the Chernobyl accident, and its actions have reinforced my conviction that the IAEA is an invaluable body for the promotion of responsible use of nuclear power throughout the world.

From the perspective of our domestic use of nuclear power, I am not surprised that the accident at Chernobyl has caused us to once again assess the adequacy of the designs, safety features, and regulations of all our operating nuclear reactors. The Department of Energy has already responded by summoning numerous in-house and independent reviews of the safety of its operating production reactors to determine if any safety improvements are needed in light of the Chernobyl accident.

In the commercial reactor sector, the Nuclear Regulatory Commission is closely monitoring and evaluating the causes and consequences of the Chernobyl accident, to determine if there are any lessons to be learned with respect to the regulation of our own commercial nuclear industry.

I, for one, am confident that the soul searching and self-evaluation that we are now undertaking as a result of the Chernobyl accident is healthy and will eventually lead us to a renewed confidence in our own nuclear industry. For, given the obvious differences in the technologies, safety systems, and regulations between our two countries, we will inevitably come to the conclusion that our technology is one of the finest in the world.

One need only to point to such things as the accident at Three Mile Island, where 70 percent of the core melted down, releasing millions of curies of radiation into the containment building, and yet no public health consequences resulted from that truly severe accident. And, to the fact that numerous States and counties have borrowed and used successfully the emergency response measures originally established for nuclear powerplants, in responding to nonnuclear disasters that have occurred in locations nearby to a nuclear plant.

Our technology does, in fact, work. Our regulations do serve to protect the public health and safety. We have learned from TMI and other plant events how to make our technology even better. We, in Congress, have been striving to make public liability coverage, if a severe accident were ever to occur, the most comprehensive we possibly can. More importantly, we are finally taking to task the one big area that is still broken, that of the nuclear licensing process, so that this Nation can enjoy a continued growth in the use of nuclear power that has served this country so well in the past.

Senator Metzenbaum.

Senator **METZENBAUM**. Mr. Chairman, first I would like to submit on behalf of Senator Johnston, a statement of his, as well as his letter to you.

The **CHAIRMAN**. His statement and the letter will be made a part of the record, as well as Senator Evans' statement.

[The prepared statement of Senator Johnston, his letter to the chairman, and the prepared statement of Senator Evans follow:]

## Statement of Senator J. Bennett Johnston

June 19 Hearing on
the Accident at the Chernobyl Nuclear Power Plant

Mr. Chairman, I congratulate you on your decision to hold this hearing. As we said in our letter to you of May 7 requesting the hearing, the Committee on Energy and Natural Resources should be playing a lead role in informing the public about the accident at the Chernobyl nuclear power plant.

The Committee can greatly assist the public in analyzing the implications and lessons of this accident by creating a forum where the best and most informed comment can be heard. We ought to hear all sides, including the responsible people from the Administration, so that the marketplace of ideas can operate to inform us and the public.

What ever we find as a result of this hearing or later on as more information becomes available from the Soviet Union, some things are already clear.

First, this is a human tragedy of the first magnitude. Over 20 have died by the official Soviet count, and many more may live with a real threat to their lives. Our sympathy must be with these people.

Second, the severity of this accident and the halting, indecisive actions of Soviet officialdom in acknowledging what was going on just underscore the importance of openness in the management of nuclear power. We in the United States benefit from the give and take of open criticism of the way this technology is managed in our country. This is not to say that our management system is perfect of even adequate to the task it faces and will face in the future. I am often a critic of the Nuclear Regulatory Commission, and I expect I will continue to be. But however we reform our licensing process we will want to retain the opportunity for criticism of management to be heard.

Third, while this event is without doubt a tragedy, it should not be taken as a sign that there is something so forbidding about the technology of nuclear power as to turn us away from it as a source of electricity. We need nuclear power now and we will need it much more in the future.

Chernobyl shows us that if we do not do the job of managing the technology right, there could be some very bad consequences. But nothing I have seen suggests in any way that we cannot do the job right. I remain an optimist where this technology is concerned. We are now using nuclear power in the United States to generate 16 percent of our electricity. Its safety record is exemplary.

We will contiue to work to make nuclear power a servant of economic growth and well being. Our job in the Committee is to determine how to use what has happened at Chernobyl to assist us in this very important work.

Mr. Chairman, I ask that a copy of our letter of May 7 be inserted in the record of this hearing.

JAMES A. McCLURE, IDAHO, CHAIRMAN
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MALCOLM WALLOP, WYOMING
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United States Senate
COMMITTEE ON
ENERGY AND NATURAL RESOURCES
WASHINGTON, DC 20510

May 7, 1986

Honorable James A. McClure
Chairman
Committee on Energy and Natural Resources
U. S. Senate
Washington, D. C. 20510

Dear Jim:

The accident at the Soviet nuclear power station at Chernobyl has captured the attention of the American public and has received unprecedented media coverage. In fact, the media has been the major source of information on the accident and its implications for the U. S. nuclear power and nuclear weapons programs. Comment and analysis from official U. S. sources has been fragmented and often overshadowed by media reports.

We believe that the Committee on Energy and Natural Resources should be playing a lead role in informing the public about this accident and in analyzing its lessons by bringing together the best and most informed comment, including the official views of the Department of Energy and other relevant Federal agencies. We do not believe that this role should be left to other Committees whose expertise and jurisdictional responsibilities with respect to nuclear matters are far different from our own.

Accordingly, we ask that you convene a series of hearings at the earliest possible date, hopefully before the coming recess, to thoroughly analyze the implications of the Chernobyl accident for

- public health and safety in the U. S., in the Soviet Union and in Eastern Europe;

- management and regulation of domestic nuclear reactors, especially those most like the ones at Chernobyl; the plutonium production reactors operated by the Department of Energy;

- plans in the U. S. to reform the nuclear reactor licensing process and to extend and revise the Price-Anderson Act;

- the foreign reactor market that U. S. vendors have been seeking to reestablish; and

- future energy supplies, including effects on the world market for fossil fuels, as a result of possible Soviet decisions or decisions in other countries to lessen reliance on nuclear power in the short and long term.

We look forward to working with you on this most important matter.

With kindest personal regards,

Sincerely,

Bennett
J. Bennett Johnston
Ranking Minority Member

Wendell
Wendell H. Ford
United States Senator

Dale
Dale Bumpers
United States Senator

Howard M. Metzenbaum
United States Senator

John
John Melcher
United States Senator

Bill
Bill Bradley
United States Senator

Jeff
Jeff Bingaman
United States Senator

Jay
Jay Rockefeller
United States Senator

## STATEMENT BY SENATOR DANIEL J. EVANS
## OVERSIGHT HEARINGS ON CHERNOBYL ACCIDENT
## JUNE 19, 1986
## SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES

As the Senator from the state that has the only graphite-moderated reactor in the country, I have a keen interest in the subject. The N-Reactor at Hanford began operation in 1964, and has had a good operating record over the past 20-plus years. It has also created a huge amount of inexpensive electricity for the ratepayers of the Pacific Northwest through the utilization of steam byproduct, besides producing weapons materials for our defense needs. I don't think that such a record justifies the immediate shut-down of the reactor. Until there is strong and ample evidence to the contrary, I believe the plant should continue to operate.

I am concerned, however, about the implications of the Chernobyl accident in the Soviet Union, as I think anyone familiar with the nuclear power industry should be. But it is difficult to make rational decisions until the Soviets provide us with an adequate scientific explanation of the causes and nature of the accident. I understand that the Soviets will not make such a presentation to the IAEA until mid or late August.

It is very important to conduct studies of the N-Reactor's safety and operating record in order to present the objective facts to the uneasy citizens in my state. At last count, there are six studies being carried out today. The first study on the fire prevention and safety systems, which was released several weeks ago, called for some modest improvements in some of the monitoring systems. The next study on the basic design of the reactor, and modifications made to it since 1964, is due out at the end of this month. I believe that the DOE, and the Congress, should follow up quickly to provide the funding to implement any recommendations coming from these studies.

We also must address through these studies the more fundamental problem of the life extension of the N-Reactor. We must ask ourselves when examining the results of these studies if it is in the public health and safety interest to prolong the life of this reactor, or whether we should proceed to consider authorizing a new production reactor? I understand the budget difficulties that our Government faces today, which led to a decision to extend the life of the present graphite core. But safety should be paramount to the budgetary questions in this matter, in my view. And, in this instance, you can't measure public health and safety in dollars and cents.

## STATEMENT OF HON. HOWARD M. METZENBAUM, A U.S. SENATOR FROM THE STATE OF OHIO

Senator METZENBAUM. Mr. Chairman, I want to commend you for holding these hearings. I wrote to you urging that you do so, and I think a number of other Senators did, as well.

I must make a prefatory statement, however, in connection with your own statement, and that is, Mr. Chairman, I do not think we can be sanguine. I do not think we can be so confident that our own agencies are doing the job that they should be doing, or that the international agencies are doing the job that they should be doing.

It is comforting to recite the words, and we look back at Three Mile Island and feel a great sense of gratification that nothing worse happened. But, the fact is that it was so close to being something worse, maybe we just skidded by or got by.

There is a lot to be learned from the Chernobyl accident, and a lot to be learned about that accident. One immediate lesson is quite clear: a severe accident resulting in massive releases of radiation, widespread evacuations, and numerous civilian deaths can indeed occur.

I will be interested in hearing today what our agencies did in connection with this, how promptly they moved and whether or not they were able to find out how much radiation had reached some of the other nations of the European sector, or whether or not they just sat back and waited for others to supply the information.

I cannot overlook the fact that there are well over 300,000 American servicemen, plus their families, living in the European theater, and there was a certain amount of exposure. Should some of those wives have come home, particularly the pregnant ones; should some of the children have come home? I don't know.

Americans living near nuclear facilities, however, are rightfully concerned that a tragedy like Chernobyl could happen to them. They expect that everything possible will be done to prevent a severe nuclear accident and that effective emergency plans are in place in case one does occur.

My research in the history of the nuclear industry is not reassuring. Because in the first instance we started off with the Atomic Energy Commission, which had a twofold responsibility. One part of that responsibility was to sell and encourage the use of atomic energy, and the second part of the responsibility was to concern itself with the safety of Americans.

But the fact is, very little was done with respect to the second part, and much more was done with promoting the use of nuclear energy. And then as time went on, it caught up with us and some of the plants in this country have had to be closed down because they were not safe enough.

I remember so vividly a headline across the top of the Plain Dealer in Cleveland, some years ago, which recited the fact, "Davis-Besse Nuclear Facility has 1,400 Defects."

I remember just recently, I went down to one of the plants down near Cincinnati, and found that there had been a leakage there. Fortunately, they were able to catch it.

But all of this causes me concern; makes me believe that it should result in more emphasis on safety and emergency planning in this Nation and a reevaluation of the current approach of risk assessment which serves as the basis for estimating the effectiveness of safety measures at nuclear facilities.

I am frank to say that I am not confident that those who have a responsibility in this area are not more concerned about stepping on the toes of the nuclear energy, or in somehow affecting the nuclear energy industry than they are concerned about the health and safety of American people.

Incredibly, industry and Government have responded to the Chernobyl accident with a fortresslike mentality.

They tell us that the probability of a severe accident is already so low that there is no undue level of risk and nothing more needs to be done to make plants safe.

The Chief of Staff of the NRC said, "We see nothing coming out of this accident to suggest we need to change." To that I just respond—I cannot believe you said it.

This manifests an air of unbelievable, dangerous complacency. The record does not justify this complacency.

Accidents which the NRC deems to be incredible, that is of such low probability that plants do not have to be designed for them, keep occurring. Time after time after time, we have an accident or a near miss caused or complicated by unquantifiable factors such as poor management, human error, regulatory violations and poor design or construction.

These experiences argue for more aggressive, rather than more relaxed, efforts to improve safety. Yet, the NRC, at the urging of the nuclear industry, has engaged in defacto regulation, and effectively halted all efforts to improve safety.

The residents of the State of Ohio have a justified concern about the NRC's effectiveness. Ohio has hosted the Zimmer Plant, the Davis-Besse Plant, and the Perry Nuclear Plant. One facility has been abandoned due to poor construction, another suffered the most serious accident in the United States since Three Mile Island, and the third is involved in a controversy relating to its location near an earthquake fault.

Many Ohio residents feel poor regulation by the NRC is responsible for many of the problems which have occurred.

All of this leads me to conclude that the public is not receiving the kind of protection it deserves.

In human terms, the Chernobyl accident was a tragedy. Estimates of cancers and fatal cancers resulting from the accident range from the tens of thousands to the hundreds of thousands.

Out in the West, there is a man by the name of Dr. John Goffman. Dr. John Goffman was one of the atomic scientists involved at Los Alamos. Dr. John Goffman was one of those involved at the Livermore Laboratory and had a high-ranking position. Today, he is professor emeritus of medical physics at the University of California at Berkeley.

I remember when Dr. Goffman lost his subvention from the U.S. Government because he was asked to do an investigation of the safety and usage of nuclear energy in this country. He came up with the wrong report. He came up with a report that his superiors did not like and his subvention was immediately cut off.

Now Dr. Goffman has estimated that Chernobyl will result in 320,000 fatal, and 320,000 nonfatal cancers. I do not think there is anybody in the country that would question the experience, the reputation of Dr. Goffman.

I am concerned today that we will be told there is no problem and that this accident has little relevance to our Nation and its nuclear program. Such a response will not be adequate.

We do not have to point to the problems we experienced with the space shuttle. We have a very serious problem of technology right before this committee. Unless agency and industry officials are doing all that they should be doing to prevent a repeat of this tragedy, it will be up to this committee and Congress to step in and take action.

We can turn our eyes away from the fact, we can close our ears, but the truth is, a problem exists unless those who are charged with the responsibility by our Government do all that they should be doing.

This committee has a responsibility to ensure that public health and safety is protected. We cannot afford to shirk our duty in this instance.

I am looking forward to learning about the Chernobyl accident, and I also hope the Government and industry officials will learn the lessons of Chernobyl and quickly undertake new initiatives to improve safety, openness and emergency planning at commercial and Federal facilities.

Thank you.

[The prepared statement of Senator Metzenbaum follows:]

*U. S. Senator Howard M.*
*METZENBAUM*
*of Ohio*

Committees:
Budget
Energy and Natural Resources
Human Resources
Judiciary

202 224 2315

STATEMENT OF SENATOR HOWARD M. METZENBAUM
SENATE ENERGY AND NATURAL RESOURCES COMMITTEE
JUNE 19, 1986

Mr. Chairman, I want to commend you for holding these hearings today.

There is a lot to be learned about the Chernobyl accident, and a lot to be learned from it.

One immediate lesson is quite clear: a severe accident resulting in massive releases of radiation, widespread evacuations and numerous civilian deaths can indeed occur.

Americans living near nuclear facilities are rightfully concerned that a tragedy like Chernobyl could happen to them. They expect that everything possible will be done to prevent a severe nuclear accident, and that effective emergency plans are in place in case one does occur.

All of this should result in more emphasis on safety and emergency planning in this nation, and a re-evaluation of the current approach to risk assessment, which serves as the basis for estimating the effectiveness of safety measures at nuclear facilities.

Yet, incredibly, industry and the government have responded to the accident with a fortress-like mentality.

They tell us that the probability of a severe accident is already so low that there is no undue level of risk and nothing more needs to be done to make plants safe.

The Executive Director for Operations of the NRC said: "W see nothing coming out of this accident to suggest we need to change."

This manifests an air of dangerous complacency.

Yet, the record does not justify this complacency.

Accidents which the NRC deems to be "incredible" - that is, of such low probability that plants do not have to be designed for them - keep occurring. Time after time, we have an accident or a near miss caused or complicated by unquantifiable factors such as poor management, human error, regulatory violations and poor design or construction.

These experiences argue for more aggressive, rather than more relaxed, efforts to improve safety.

Yet, the NRC, at the urging of the nuclear industry, has engaged in de-facto deregulation, and effectively halted all efforts to improve safety.

The residents of the state of Ohio have a justified concern about the NRC's effectiveness. Ohio has hosted the Zimmer plant, the Davis-Besse plant, and the Perry nuclear plant. One facility has been abandoned due to poor construction, another suffered the most serious accident in the U.S. since Three Mile Island, and the third is involved in a controversy relating to its location near an earthquake fault. Many Ohio residents feel poor regulation by the NRC is responsible for many of the problems which have occurred.

All of this leads me to conclude that the public is not receiving the kind of protection it deserves.

In human terms, the Chernobyl accident was a tragedy.

Estimates of cancers and fatal cancers resulting from the accident range from the tens of thousands to the hundreds of thousands.

Dr. John Gofman, Professor Emeritus of Medical Physics at the University of California at Berkeley has estimated that Chernobyl will result in 320,000 fatal and 320,000 non-fatal cancers.

Yet, I am concerned that today we will be told there is no problem and that this accident has little relevance to our nation and its nuclear program.

Such a response will not be adequate.

We don't have to point to the problems we experienced with the space shuttle.

We have a very serious problem of technology right before this Committee, and unless agency and industry officials are doing all that they should be doing to prevent a repeat of this tragedy, it will be up to this Committee and Congress to step in and take action.

This Committee has a responsibility to ensure that public health and safety is protected. We cannot afford to shirk our duty in this instance.

I am looking forward to learning more about the Chernobyl accident.

I also hope that both government and industry officials will learn the lessons of Chernobyl and quickly undertake new initiatives to improve safety, openess and emergency planning at commercial and federal facilities.

The CHAIRMAN. You have started on a range of opinion. I understand that that is part of the public dialog that is going on. I have likened the situation in the nuclear industry today by saying, yes, there is indeed a risk as there is to all of life. But it is not perfect in its record, as indeed nothing in life is perfect.

Often times, we, in our political debates, use the old illustration of a half of glass of water and say, "Is the glass half full or half empty?" This is a glass of water that is better than 99 percent full and less than 1 percent empty, and are we going to look at the glass and say, "That is not completely full," and throw it away while we are thirsty.

Let's do with the Salk vaccine for polio. It is not perfect; there are a few people who get polio. There is substantial risk to public health and human condition because of a whole variety of situations in our society.

We debate the 55 mile per hour speed limit, knowing that raising it to 70 will cause more deaths on the highway, and cutting it to 35 would save some. We make some trade-offs in our society measuring the greater risks, or the greater costs to society.

There is a cost to not having safe energy and there is a cost to not having sufficient energy. There are costs in any of the decisions that we made. It is a lot easier to play the negative than it is to play the positive.

It is a lot easier to sell fear than it is to sell confidence. I notice that some people recently, a very prominent scientist has written an article that has received wide publicity, saying American technology has failed and he points to the failures that are obvious.

But, American technology has succeeded dramatically in a whole host of things that make our life safer, more comfortable, rich and more rewarding.

Is the glass 99 percent full, or 1 percent empty? I do not know what the appropriate proportions are and I certainly am not complacent about safety in the nuclear power field any more than I am complacent about safety in dam design.

We have just observed the 10th anniversary of the failure of the Teton Dam in Idaho that caused the loss of 11 lives and $0.5 billion worth of damage, but we have not drained every dam in the country. We do not live in fear, below every dam. We know that there are earthquakes that cause problems and earthquake scientists predict that there will be severe earthquakes in California, but we have not evacuated California.

Although some suggest it.

I am confident that with the help of the Senator from Ohio and others, that we are not going to see anything brushed under the rug in the investigation of the procedures we use with the nuclear industry, nor am I suggesting that it should be.

I think I have been as insistent as anyone has been or should be with respect to examining the safety features of our industry; doing what we reasonably can do to make certain that we take the actions that are necessary, appropriate the money that we have to appropriate, create the programs that are necessary to give the people of this country assurance that we are doing what can reasonably be done with respect to safety in this industry.

Yes, I am not satisfied with everything we have done, nor should we be, and I am not complacent about it. But, I do believe we need to put it into some kind of perspective and this hearing today is an effort to allow the American public to hear from people who know what the facts are so that we can put it into the appropriate perspective and take the appropriate actions that are necessary with respect to our own industry.

But, above all, I believe the American public should understand what Chernobyl is, what it means and what it is not, and what it does not mean.

Senator **Metzenbaum**. Mr. Chairman, I do not think the issue is whether we close down all of our nuclear facilities, or do not close them down.

I do not think anybody advocates closing them all down.

The **Chairman**. Some do.

Senator **Metzenbaum**. Well, let me say that I believe the issue is: Are we doing everything that is humanly possible to see to it that those facilities that are operating——

The **Chairman**. We are not doing everything that is humanly possible to make certain that Salk vaccine does not infect somebody. We are not doing everything that is humanly possible to keep people from dying—the largest cause of death, violent death in the United States is on our highways and we are not doing everything that is human possible to stop death on the highways.

We are making measured, reasoned responses to risk.

Senator **Metzenbaum**. Mr. Chairman, I think that comparisons sometimes do not work. I do not believe that you appreciate—no, I will withdraw that.

I know that you appreciate the distinction between some risks and the kinds of risks that are involved in connection with nuclear accidents. You mentioned the problem at the Teton Dam, 11 deaths. We are not talking about 11 deaths if there is an accident or problem at one of our nuclear facilities. We are talking about thousands and thousands of deaths. We are talking about long-range suffering. We are talking about evacuating entire communities, and I will conclude by saying, using your own analogy to that half a glass of water—whether it is half full or half empty—I think the real issue is—and it is not a question of whether it is 99 percent full. The real issue is, what kind of water is in there? Is the water tainted? Have we done everything we can to see to it that the water that we drink is as pure as it possibly can be?

I am not sure, by your examining that particular glass that you can always be able to tell just by looking at the nuclear facility, nor at the water, whether it is as safe as it should be.

The **Chairman**. I would say to my friend from Ohio, that if we applied the same test to that water that we now apply to the nuclear industry, I would chuck it out. It could not possibly pass the test. And we have the Clean Drinking Water Act, too. You and I helped write that, and we are enhancing the safety of the water supplies to the people of this country.

But we have no way the same level of confidence, the purity of that water, than we have in the safety of nuclear industry.

Senator **Metzenbaum**. As the ringmaster of the show, maybe we ought to say, "On with the show."

The CHAIRMAN. I do look forward to hearing from the witnesses, but that is one of the things that I think is essentially from my own standpoint; that we understand what the hearings are trying to do, and that is get facts and not hype emotions.

With that, we will call our first panel. The first panel consists of Mr. Sheldon Meyers, Acting Director, Office of Radiation Programs, the Environmental Protection Agency; Mr. Harold Denton, Director, Office of Nuclear Reactor Regulation, of the NRC; and from the Department of Energy, Ms. Mary Walker, Assistant Secretary, Environment, Safety and Health; Dr. Delbert Bunch, Deputy Assistant Secretary, Reactor Deployment; Mr. Troy Wade, Manager, DOE-Idaho Operations Office, U.S. Department of Energy.

If you ladies and gentlemen will take your place at the witness table, please.

I would note that there are several people who have accompanied these witnesses who may be called upon to supply answers or information. They are seated in the front row and available for consultation, if that is necessary.

The prepared statements of each of you will be placed in the record in full, and if you can summarize, hit the high points, make the points that you think are essential, we would appreciate it.

We will start with Mr. Meyers.

## STATEMENT OF SHELDON MEYERS, ACTING DIRECTOR, OFFICE OF RADIATION PROGRAMS, ENVIRONMENTAL PROTECTION AGENCY

Mr. MEYERS. Good morning, Mr. Chairman, and members of the committee. I am going to describe for you this morning the activities of the President's Interagency Task Force on the Soviet Nuclear Accident, and also describe for you EPA's environmental radiation monitoring system, otherwise known as ERAMS, which was instrumental in collecting data in this country as a result of the accident in the U.S.S.R.

As you have already stated, the accident occurred at approximately 1:30 a.m., Saturday, April 26. On Monday, April 28, the first reports were received from Sweden, indicating that a significant increase in levels of radioactivity were detected and they suspected a major nuclear accident had occurred in a powerplant in the Soviet Union.

President Reagan established the Interagency Task Force on the accident on Tuesday, April 29. Lee Thomas, Administrator of EPA was named to head the task force. The task force included representatives from 15 departments and agencies.

Meetings were held daily from April 30 through May 14, with the exception of May 10, 11, and 13: and on May 14, it was decided that further meetings were not warranted unless something unforeseen took place.

The work of the task force was to assess the accident and the situation in Europe, to monitor environmental radioactivity levels in this country, to determine the potential for health and environmental effects, and to provide the best and most current information to public officials, the press, and to the U.S. citizenry.

We accomplished our work by collecting available foreign and domestic information, evaluating and interpreting the data, and then coordinating the Federal response and the dissemination of the information to the public.

Key agency contacts were designated to respond to specific types of public inquiries, and a daily task force report on the Soviet nuclear accident was issued by EPA from April 29 through May 23.

The response effort at EPA was organized into three groups; data receipt, evaluation, and interpretation: data reporting and operations support. This was essentially staffed through Mr. Thomas in his capacity as chairman.

EPA was the centralized collection point for data on the international levels of radiation, for monitoring data obtained from DOE's national laboratories, from the National Oceanographic and Atmospheric Administration on atmospheric air levels, from EPA's own ERAMS system, and also from State monitoring, from U.S. Embassies or diplomatic posts via the State Department, and U.S. scientific monitoring teams abroad.

A Health Working Group, under the leadership of the Health and Human Services Department was formed and tasked to examine potential long- and short-term health effects, to identify symptoms and effects, and to distribute information to health officials around the country.

The assessment of agricultural and food effects was also a responsibility of this work group.

A work group of the task force headed by NRC was given the responsibility to describe and evaluate possible reactor accident scenarios. NOAA was responsible for providing the meteorological information that was also included in the daily task force report.

EPA was responsible for public information, issuing the daily task force report, and providing information to the public as it became available.

Also, EPA headed the Dose Assessment Working Group, which consisted of representatives from several agencies.

On May 1, the State Department issued a travel advisory recommending against travel to Kiev and adjacent areas in the Soviet Union and urging the public to monitor press reports for any updated information.

The following day, the State Department upgraded its travel advisory to recommend against travel by women of childbearing age and children to Poland until the situation there was clarified, and also advised travelers in Eastern Europe to avoid consumption of milk and dairy products.

The task force decided that contact should be made with counterpart agencies in affected countries to obtain radiological data.

NRC placed calls to 18 countries between May 2 and May 5 and the best available information was included in the daily task force report.

On May 3, the State Department sent cables to diplomatic posts to request available radiological data be sent to the United States.

The United States dispatched scientists to make environmental measurements in United States Embassies and consulates in selected sities in the U.S.S.R, Poland, and Hungary on May 3. EPA scientist Richard Hopper went to Warsaw and Krakow, Poland, Budapest, Hungary, and Sofia, Bulgaria.

A military team was dispatched to the Soviet Union to take measurements in the Moscow Embassy and in Leningrad. I bring this up because we were getting essentially no information from Russia, itself, while on the other hand, we were getting information from the Western countries.

Sampling frequency in the United States for radioactive airborne particulates was increased from twice weekly to daily in EPA's ERAMS on April 29. The Canadian air monitoring network also increased their sampling to daily.

On April 30, collection of rainwater samples was increased to daily and collection of milk samples was increased from monthly to twice weekly.

At this time, let me expand on the ERAMS System, itself. The ERAMS has been in place since 1973, when several separate but related radiation monitoring networks were combined. The ERAMS collection and analyses of environmental samples constitutes the Nation's single major continuous source of environmental radiation data acquisition and analyses. It operates all the time. For the Chernobyl incident, we merely speeded it up.

It is a cooperative program between the States and local governments which collect the samples, and the EPA, which performs the analysis using verified, analytical quality assured techniques.

ERAMS consists of 268 sampling locations, which routinely collect environmental data on air particulates, precipitation, milk, drinking water, and surface water. The air particulate and drinking water stations take samples representative of about 30 percent of the American population, while the milk sampling stations cover over 40 percent of the milk consumed in the United States today.

We have sampling stations in all 50 States, Puerto Rico, and the Canal Zone.

Radiation analyses are performed on ERAMS samples and include gross alpha and gross beta levels, gamma analyses for fission products, and specific analyses for uranium, plutonium, strontium, iodine, radium, krypton, and tritium.

Special consideration is given to certain radionuclides, such as iodine, cesium, and strontium because one would expect to find these radionuclides in fallout of fresh fission products such as those emitted from the Soviet nuclear reactor accident, and gross beta in air particulates for screening or early warning procedures.

Each of these radionuclides also have biological significance; iodine concentrates in the thyroid, cesium in lean flesh, and strontium in bone. These radionuclides are also readily passed into the milk supply.

Typical ambient levels of radioactive iodine in air and milk are normally near zero due to its short half-life and resulting decay. Cesium and strontium persist in the environment for longer periods of time due to their longer half-lives.

The first reports of elevated radiation in the United States from the accident——

Senator METZENBAUM. Mr. Chairman.

The CHAIRMAN. Excuse me, Mr. Meyers. Senator Metzenbaum.

Senator METZENBAUM. Mr. Chairman, I thought you had asked the witnesses—I am afraid if we wait for each of the witnesses to read their entire statements, as Mr. Meyers is doing, there will be no opportunity for questioning. I thought they were asked by you to summarize their statements.

The CHAIRMAN. Mr. Meyers, is it possible to give us some high points and summarize briefly? I think all the press have copies of the statements; statements are available from all witnesses.

Mr. MEYERS. Yes, sir. Let me just quickly give you some readings that we did get. The daily precipitation samples showed a number of cities with detectable levels of iodine-131 resulting from the nuclear reactor accident. The highest deposition level reported was 12,300 picocuries per square meter, in Montpelier, VT.

As a frame of reference, the U.S. Food and Drug Administration's protective action recommendations for ground water depositions of iodine-131 is 130,000 picocuries per square meter. This is a level that FDA recommends for local public health officials to take protective action to avoid domestic food contaminationn. Thus, the 12,300 level represented less than 10 percent of the FDA level and was not considered to pose any threat to the public health or welfare.

While we will continue to collect samples routinely, we did make arrangements for the World Health Organization to serve as the international data repository for all radiation related to the Chernobyl nuclear reactor accident, and EPA will continue to supply WHO with domestic data, but they will assume the responsibility from EPA for collecting the international data.

In closing out the work of the task force, it was decided that the involved agencies will continue to cooperate and collaborate in areas where continued activity is necessary, such as the dose assessment group, health and agricultural working group, and finally, a summary health and dose assessment report will be prepared. Thank you, Mr. Chairman.

[The prepared statement of Mr. Meyers follows:]

STATEMENT OF
MR. SHELDON MEYERS
ACTING DIRECTOR
OFFICE OF RADIATION PROGRAMS
U.S. ENVIRONMENTAL PROTECTION AGENCY
BEFORE THE
COMMITTEE ON ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE

June 19, 1986

Good morning, Mr. Chairman and members of the Committee. My name is Sheldon Meyers; I am Acting Director of EPA's Office of Radiation Programs. I will discuss the activities of the President's Interagency Task Force on the Soviet Nuclear Accident and also describe for you EPA's environmental radiation ambient monitoring system, otherwise known as ERAMS.

The accident occurred at approximately 1:30 AM, Saturday, April 26, 1986. On Monday, April 28 the first reports were received from Sweden indicating that a major nuclear accident had occurred at a power plant in the U.S.S.R.

President Reagan established the Interagency Task Force on the Soviet Nuclear Accident on Tuesday, April 29th. Lee Thomas, Administrator of the U.S. Environmental Protection Agency was named to head the Task Force. The Task Force included representatives from fifteen Departments and Agencies. Meetings were held daily from April 30 through May 16 (with the exception of May 10, 11, and 13) at which time it was decided further meetings were not warranted.

The work of the Task Force was to assess the accident and the situation in Europe, to monitor environmental radioactivity levels in this country, to determine the potential for health and environmental effects here and abroad, and to provide the best and most current information to public officials, the press, and U.S. citizens.

We accomplished our work by collecting available foreign and domestic information, evaluating and interpreting the data, and then coordinating the Federal response and the dissemination of the information to the public. Key agency contacts were designated to respond to specific types of public inquiries and a daily Task Force Report on the Soviet Nuclear Accident was issued by EPA from April 29 through May 23.

The response effort at EPA was organized into three groups: data receipt, evaluation and interpretation; data reporting; and operations support.

EPA was the centralized collection point for data on international levels of radiation, from monitoring data obtained from DOE's National Laboratories, from NOAA on atmospheric air levels, from EPA's ERAMS, from State monitoring, and from U.S. embassies or diplomatic posts via the State Department and the U.S. scientific monitoring teams.

A Health Working Group under the leadership of HHS was formed and tasked to examine potential long and short-term health effects, identify symptoms and effects, and distribute information to health officials. The assessment of agricultural and food effects was also a responsibility of this working group.

A work group of the Task Force headed by NRC was given the responsibility to describe and evaluate possible reactor accident scenarios.

NOAA was responsible for providing the meteorological information that was also included in the daily Task Force Report.

EPA was responsible for public information: issuing the daily Task Force Report and providing information to the public as it became available. Also EPA headed the Dose Assessment Working Group which consisted of representatives from several Federal agencies.

On May 1 the State Department issued a travel advisory recommending against travel to Kiev and adjacent areas in the Soviet Union and urging the public to monitor press reports for any updated information. The following day the State Department upgraded its travel advisory to recommend against travel by women of child-bearing age and children to Poland until the situation there was clarified and also advised travelers in Eastern Europe to avoid consumption of milk and dairy products.

The Task Force decided that contacts should be made with counterpart agencies in affected countries to obtain radiological data. NRC placed calls to eighteen countries between May 2 and May 5. The best available information was included in the daily Task Force Report.

On May 3 the State Department sent cables to diplomatic posts to request available radiological data be sent to the United States.

The U.S. dispatched scientists to make environmental measurements in U.S. embassies and consulates in selected cities in the U.S.S.R., Poland, and Hungary on May 3. EPA scientist Richard Hopper went to Warsaw and Krakow, Poland, Budapest, Hungary, and Sophia, Bulgaria. A military team was dispatched to the Soviet Union. (Levels at several times background were reported at each location visited.)

Sampling frequency in the U.S. for radioactive airborne particulates was increased from twice weekly to daily in EPA's ERAMS on April 29. The Canadian air monitoring network also increased their sampling to daily. On April 30 collection of rain water samples was increased to daily; collection of milk samples was increased from monthly to twice weekly.

I would like to expand on the ERAMS system. The ERAMS has been in place since 1973 when several separate, but related radiation monitoring networks were combined. The ERAMS collection and analyses of environmental samples constitutes the Nation's single major continuous source of environmental radiation data acquisition and analyses. It is a cooperative program between the States and local governments which collect the samples, and the EPA which performs the analyses using verified analytical and quality assurance procedures.

ERAMS consists of 268 sampling locations which routinely collect environmental data on air particulates, precipitation, milk, drinking water, and surface water. The air particulate and drinking water stations take samples representative of about 30 percent of the American population, while the milk sampling stations cover over 40 percent of the milk consumed by U.S. citizens.

Radiation analyses are performed on ERAMS samples and include gross alpha and gross beta levels, gamma analyses for fission products and specific analyses for uranium, plutonium, strontium, iodine, radium, krypton, and tritium. Special consideration is given to certain radionuclides, such as gross beta in air particulates for screening or early warning procedures, and iodine, cesium, and strontium because one would expect to find these radionuclides in fallout of fresh fission products such as those emitted from the Soviet nuclear reactor accident.

Each of these radionuclides also has biological significance; iodine concentrates in the thyroid, cesium in lean flesh, and strontium in bone. These radionuclides are also readily passed into the milk supply.

Typical ambient levels of radioactive iodine in air and milk are near zero due to its short half life and resulting decay. Cesium and strontium persist in the environment for a longer period of time, due to their longer half lives.

The first elevated levels of radiation in the U.S. from the accident were received from the Pacific Northwest Laboratory in Richland, Washington, on May 5. ERAMS detected the first elevated levels of radioactivity in air at ground level in the U.S. on May 7.

The daily precipitation (rainwater) samples showed a number of cities with detectable levels of iodine-131 resulting from the nuclear reactor accident. The highest deposition level reported was 12,300 picocuries per square meter (pCi/m2) in Montpelier, Vermont.

As a frame of reference, the U.S. Food and Drug Administration's protective action recommendations for ground water deposits of iodine-131 is 130,000 pCi/m2. This is the level that FDA recommends for local public health officials to take protective action to avoid domestic food contamination. Thus, the 12,300 level represented less than ten percent of the FDA level and was not considered to pose any threat to public health or welfare.

The Governor of the State of Oregon issued an advisory May 7 for people who used rainwater as their sole source of drinking water to refrain from drinking rainwater at that time. The first positive milk samples were reported by ERAMS on May 13.

The Task Force Report later concluded that the U.S. radiation monitoring network had recorded sporadic and detectable levels of radiation from the Soviet accident in most areas of the country but these levels posed no health or environmental threat.

Other activities of the Task Force include the following: EPA acted as the clearinghouse for offers of assistance and coordinated this activity with the State Department.

FAA requested and received measurement assistance from DOE. The CDC/FDA medical network was used to provide information to State health officers. DOE had primary responsibility for Congressional liaison on the Soviet accident.

In addition, a Dose Assessment Working Group consisting of representatives from several Federal agencies was formed.

The U.S. Department of Agriculture's Food Safety and Inspection Service and the FDA had in place routine procedures to monitor imported products. Increased monitoring and analysis of fresh fruit and vegetables, fish and selected dairy products were conducted at points of entry into the U.S. and countries who export meat and poultry products to the U.S. were notified of special monitoring procedures to undertake prior to shipment to the U.S. Working with U.S. Customs officials, particular attention was given to products from Austria, Czechoslovakia, East Germany, Finland, Hungary, Japan, Norway, Poland, the Soviet Union, Sweden, and West Germany.

FDA measurements have shown low amounts of iodine-131 and other radionuclides in imported shipments of fresh vegetable and dairy products from Europe. Two shipments of cheese exceeded the level of concern for iodine-131 for imported foods and were refused entry. Collectively, all of FDA's results would present no public health hazard to U.S. citizens.

Foreign data received suggested external radiation levels were decreasing in Western Europe beginning May 10.

The analyses for air and water were conducted on an expedited basis through the first two weeks of June. The collection and analyses of milk samples will continue on an expedited basis until samples wind down to normal radiation levels, at which time routine monitoring will be resumed through the ERAMS system.

EPA made arrangements with the World Health Organization (WHO) to serve as the international data repository for all radiation data related to the Chernobyl nuclear reactor accident. EPA will continue to provide WHO with domestic data from our ERAMS monitoring program and other sources of data until domestic data return to background levels. WHO will provide the global data base to all interested parties.

In closing out the work of the Task Force, it was decided that the involved agencies will continue to cooperate and collaborate in areas where continued activity is necessary, such as the Dose Assessment, Health, and Agriculture Working Groups. Finally, a summary health and dose assessment report will be prepared.

This concludes my formal statement.

The CHAIRMAN. Thank you, Mr. Meyers.
Mr. Denton.

## STATEMENT OF HAROLD R. DENTON, DIRECTOR, OFFICE OF NUCLEAR REACTOR REGULATION, NUCLEAR REGULATORY COMMISSION

Mr. DENTON. Thank you, Mr. Chairman. I will try to summarize my testimony briefly.

Following the formation of the task force, we created within the NRC a Chernobyl incident tracking team, using our response center, which we created after the TMI accident. That provided a way that we could serve as the clearing house for the entire world's interest in this area. We had daily contact with most of the regulators in the European countries and Japan. We supplied all the background information that we could gather to the task force with regard to the possible causes of the accident and its consequences.

As you know, we have identified significant design differences between that plant and the U.S. plants. That plant is not exported outside of Russia. It is a graphite plant, a boiling water plant, vertical pressure tubes; very different than U.S. light water plants. I could go into those differences if you so desire.

We intend to issue a report to the Commission by about the middle of July which summarizes all the information we have gathered to date. We now have access to a great deal of information that we have gathered which is in the public record, regarding the design of that plant. We are trying to look at the entire plant; what are the general design criteria in the Soviet Union, what are their approaches to QA, operating training, the licensing, what is their safety philosophy.

We hope ultimately to provide the Commission with a report on that plant and on the accident that the Commission can use in deciding whether or not design changes may be necessary.

We will be participating in the forthcoming IAEA meetings. I met with two of the Soviet designers of this plant in Vienna several weeks ago. They have promised to be fully forthcoming and cover all the details from the initiating event through the biomedical aspects.

Chairman Palladino has asked that the senior staff recommend by the end of the year whatever changes we think are necessary in our program. Based on all that we can gather, we have identified three areas which we think need a detailed look.

First, we want to look at accident prevention, to see if there is anything in the initiating event, the relationship of the Chernobyl design to U.S. design and accidents that might occur here. We intend to compare accident prevention aspects with what we require in this country.

The second area we want to look at in detail involves emergency response planning. We want to be sure we understand what happened there, how severe the accident was and what implications it might have to the United States.

By way of comparison, you might recall that TMI released 15 curies of iodine into the atmosphere; this plant released approximately 60 million curies of iodine-131 into the atmosphere.

Senator **Metzenbaum**. Would you give us the figures again?

Mr. **Denton**. At TMI there were 15 curies of iodine-131 released into the atmosphere over the course of the accident. At Chernobyl, there were approximately 60 million curies of iodine released very early in the accident.

There is a stark difference between the consequences of that accident and the TMI accident.

I might mention, Senator, you had asked about complacency within the NRC. I don't think we are complacent. It might be worth a moment to just highlight some of things we have done since TMI, to set the stage for things we think were important.

If you recall, we did establish the Federal Emergency Management Agency, so we do now have around all U.S. plants preplanned emergency planning, involving State and local officials. I think in retrospect, if we had not done that at TMI time, that would be one of the first lessons to learn from Chernobyl. I am very glad we have that sort of preplanned FEMA agency in place today.

The second thing we did following TMI was emphasize plant operations. We made the requirements for the selection of plant operators and management more stringent; there is an accreditation program for operators; we have changed procedures, strengthened all the instrumentation in the control room and made a lot of changes with regard to that area. Third, we made hardware changes; a lot of instrumentation, pumps, valves and these sort of things, to try to reduce the probability of an accident.

Overall, I think TMI cost plant operators in direct costs about $50 million per plant. That is probably $5 billion that TMI cost in terms of safety and improvement. Probably an equal amount was spent on indirect improvements following TMI, so that I would guess the total impact of TMI on improving safety in this country was probably on the order of $10 billion, everything considered.

It is not clear what Chernobyl will lead to, but we do have a task force appointed. We have people who will follow each of the various areas and we intend to supply the Commission as quickly as we can following these IAEA meetings, a complete report on what happened and what the implications are to the United States.

We think this sort of approach will provide a comprehensive, systematic assessment of the impact of the Chernobyl accident on our regulatory policies, and provide a technical basis for what changes, if any, need to be made.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Denton follows:]

Committee on Energy and Natural Resources

Testimony of Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission

June 19, 1986

Mr. Chairman, at your request, I am appearing before the Committee today on behalf of the NRC staff to present testimony on the Chernobyl Reactor Accident and our plans for evaluating its implications on regulatory practices in the United States.

At approximately 1:23 a.m. on April 26, 1986, a serious accident occurred at Unit Number 4 of the Chernobyl Nuclear Station near the city of Kiev in the U.S.S.R.

The accident involved severe damage to the reactor and the structure that housed it. As you know, only a few details have been forthcoming from the Soviet Union regarding the nature and causes of the accident. However, we do know that significant radiological releases occurred as a consequence of the accident which were ultimately detected in a large number of countries around the world. In the immediate aftermath of the accident, the Government established an interagency task force to assess and monitor the accident in order to determine its potential environmental impact on the United States. This interagency task force effort was completed on May 14, 1986.

To support the interagency task force, the NRC established the Chernobyl Incident Tracking Team. This team is now winding down its efforts and completing preparation of a draft report of its efforts.

Based on the information available to us now, we have concluded no immediate changes in our regulatory practices and policies are necessary. Information will be forthcoming from the Soviet Union this summer regarding details of the Chernobyl Unit 4 design as well as the accident scenario.

There are substantial design differences between commercial reactors in the United States and the Chernobyl reactor. These differences include a reactor enclosure philosophy that appears significantly different from the containment philosophy embodied in western-style plant designs. The reactor itself is a graphite moderated, pressure tube, boiling water design, which is considerably different from the design of light water reactors in use in the U. S. The significance of these fundamental design differences is that the nature of accident initiating events, and the way they could evolve in a plant like Chernobyl, as well as the likely magnitude of the consequences, are very different from U. S. designs.

I would now like to discuss the program the NRC is currently implementing to ensure that the full ramifications of the Chernobyl accident are completely and thoroughly assessed.

First, let me say that the need to understand the impact of the Chernobyl accident on regulatory policies and practices is not unique to the United States. All 26 countries in which nuclear power plays a role in their electrical generation are undoubtedly faced with the same questions.

Already there is an international effort underway by the International Atomic Energy Agency, with which the NRC's efforts will be closely coordinated.

Specifically, NRC will participate in several upcoming IAEA meetings over the next several months. The first will be a meeting, expected in July, during which the Soviet Union will report on the causes of the Chernobyl accident. There will also be meetings in which binding international early warning and coordination agreements will be drafted. There will be a meeting of worldwide experts that will develop and propose ways to improve safety. The final meeting will be a conference of governments convened to consider the recommendations of the experts meeting.

In addition to these meetings, there is also underway a general movement to strengthen the role of the IAEA in responding to accidents such as Chernobyl. For example, the role of the Operational Safety Assessment Review Teams will be strengthened through mechanisms such as increasing the inspection frequency. The Incident Reporting System will likewise be improved.

We have been informed that the International Nuclear Safety Advisory Group, which advises the IAEA Inspector General, will also be strengthened. Finally, other U. N.-sponsored organizations, such as the U. N. Scientific Committee on Effects of Atomic Radiation, and the World Health Organization will become more actively involved in responding to nuclear accidents.

In addition, the NRC actively participates in activities of the Committee for the Safety of Nuclear Installations, which operates under the auspices of the OECD's Nuclear Energy Agency. This Committee is beginning to become actively involved in the assessment of the Chernobyl accident.

Chairman Palladino has asked the NRC's Executive Director for Operations to appoint a group of senior NRC scientists and engineers to continue the study of the accident and recommend to the Commission any action that might be needed for the U.S. nuclear regulatory program.

Although we are still lacking information regarding the causes of the accident, it is possible to identify issues in which increased regulatory attention will likely be focused in the future. These issues can, in general, be codified into three areas. The first area deals with those issues involving accident prevention. We will be looking to identify the initiating event, the relationship of the Chernobyl plant design to the accidents and transients that could occur in plants of that design, and to assess the likelihood of such events. This relationship will be compared to U. S. plants to systematically identify any similarities and differences. We will also be examining the USSR approach to safety features that can potentially reduce radiological consequences, such as containments, and at severe accident management and accident recovery procedures.

The second area we will investigate deals with the issues involving emergency response planning. This includes international cooperation and early warning programs as well as reassessing the adequacy of current U. S. programs in light of any lessons learned from Chernobyl. We will be involved with wide range planning efforts regarding radiation assessment, food chain impacts, and other environmental impacts. Close coordination with other U. S. agencies, such as the Environmental Protection Agency and the Food and Drug Administration, will be required.

The third and last major area is source term and accident consequences. A major effort will be to examine how the radiological release mechanisms that occurred at Chernobyl apply to U. S. reactors, and whether our current models to predict radiological source terms remain valid. The validity of current meteorological models for transport of radionuclides in the atmosphere will also be investigated.

This effort may take at least six months to a year, and will involve considerable staff effort within NRC, as well as participation by scientists in our national laboratories.

I believe that this plan will provide a comprehensive, systematic assessment of the impact of the Chernobyl accident on U. S. regulatory policies and practices, and provide a sound technical basis for what, if any, changes need to be made. It will also be integrated with international efforts, so that the maximum benefit from programs can be realized.

Appended to my testimony are a description of the Chernobyl site and plant and a summary of the accident.

Thank you very much for the opportunity to testify before the Committee today. At this time both I and my staff are available to answer any questions you might have.

# ATTACHMENT TO TESTIMONY OF HAROLD DENTON BEFORE THE COMMITTEE ON ENERGY AND NATURAL RESOURCES

JUNE 19, 1986

SITE AND PLANT DESCRIPTION

THE ACCIDENT

- EVENT DESCRIPTION SUMMARY AND STATUS
- RADIOLOGICAL DATA

FUTURE PLANS

DESCRIPTION OF THE CHERNOBYL SITE

- THE CHERNOBYL REACTOR SITE IS A 4 UNIT SITE LOCATED ON THE PRIPYAT RIVER APPROXIMATELY 10 MILES NORTHWEST OF CHERNOBYL

- CHERNOBYL IS A SMALL TOWN LOCATED APPROXIMATELY 60 MILES NORTH OF KIEV

- POPULATIONS

  - KIEV - 2½ MILLION

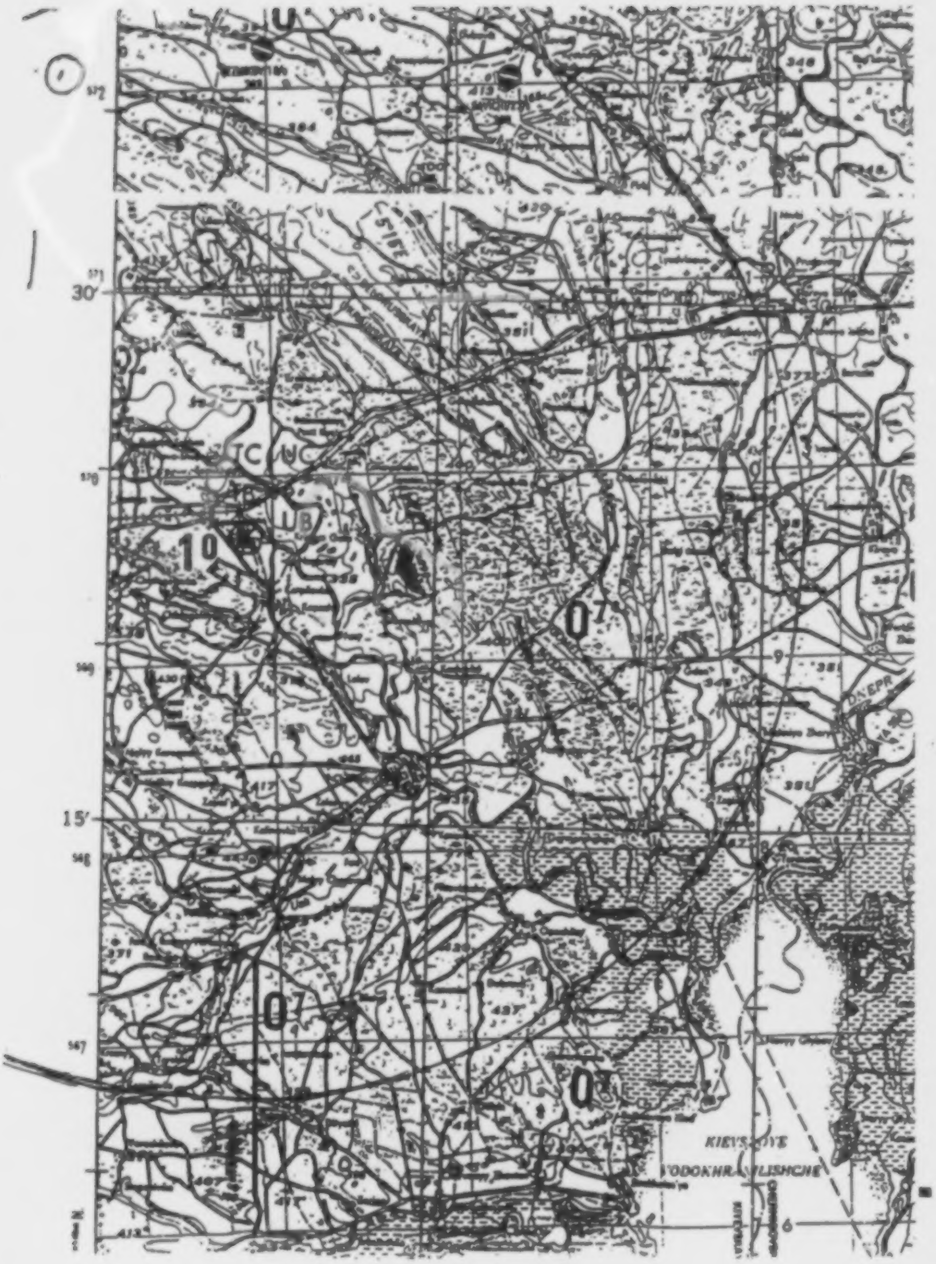
  - PRIPYAT + 3 OTHER NEARBY TOWNS - 49,000
    WITHIN 18 MILE RADIUS - 150,000 TO 180,000

  - WITHIN A 100 MILE RADIUS - 7 MILLION

- TERRAIN APPEARS TO BE ROLLING HILLS

- ALL FOUR UNITS ARE RBMK-1000 CLASS PLANTS. UNIT 1 OPERATIONAL AROUND 1981, UNIT 4 OPERATIONAL IN 1983. TWO MORE RBMK-1000 CLASS UNITS CURRENTLY UNDER CONSTRUCTION AT SITE.

- APPROXIMATELY 1 DOZEN RBMK-1000 CLASS UNITS CURRENTLY IN OPERATION IN SOVIET UNION


①
30'
15'
10
0
0
0
DNEPR
KIEVSKOYE
VODOKHRANILISHCHE
6

CHERNOBYL PLANT CHARACTERISTICS*

- RBMK-1000 PLANT DESIGN IS SIGNIFICANTLY DIFFERENT FROM COMMERCIAL U.S. REACTORS

- THE CHERNOBYL UNITS (RUSSIAN NAME RBMK-1000) ARE DIRECT CYCLE BOILING-WATER PRESSURE-TUBE REACTORS

- EACH UNIT IS RATED AT ABOUT 3200 MWT

- THE REACTOR FUEL IS CONTAINED IN A LARGE NUMBER (~1660) OF INDIVIDUAL ZIRCALOY PRESSURE TUBES IMBEDDED IN A MATRIX OF GRAPHITE BLOCKS.

- EACH PRESSURE TUBE CONTAINS 18 ZIRCALOY CLAD $UO_2$ FUEL PINS ENRICHED TO ABOUT 1.8% U-235. THE PRESSURE TUBES ARE 8.8 CM (3.5 INCH) IN DIAMETER.

- THE REACTOR IS ABOUT 12M (~40 FT) IN DIAMETER AND 8M (~26FT) HIGH INCLUDING SIDE AND TOP GRAPHITE REFLECTORS

- THE GRAPHITE MATRIX IS ENCLOSED WITHIN AN INERTED ATMOSHPERE

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*ALL INFORMATION OBTAINED FROM AVAILABLE LITERATURE

- SIX OPERATING PUMPS (8 PUMPS TOTAL, TWO PUMPS ARE ON STANDBY) CIRCULATE COOLING WATER TO THE INLET OF EACH INDIVIDUAL PRESSURE TUBE (FUEL ASSEMBLY) THROUGH INDIVIDUAL LINES FOR EACH ASSEMBLY

- STEAM IS PRODUCED WITHIN THE ASSEMBLY AND IS EXTRACTED FROM THE TOP OF EACH PRESSURE TUBE AND COLLECTED IN A HEADER COMMON TO ONE OF FOUR STEAM DRUMS

- CONTROL IS ACCOMPLISHED WITH 211 BORON CARBIDE CONTROL RODS

- THE CONTROL ROD CHANNELS ARE COOLED SEPARATELY

- ON LINE REFUELING (ESSENTIALLY CONTINUOUS)

- EMERGENCY COOLING SYSTEMS ARE DESIGNED FOR MAIN COOLANT PIPE BREAK

- 3 DIESEL GENERATORS FOR 2 UNITS

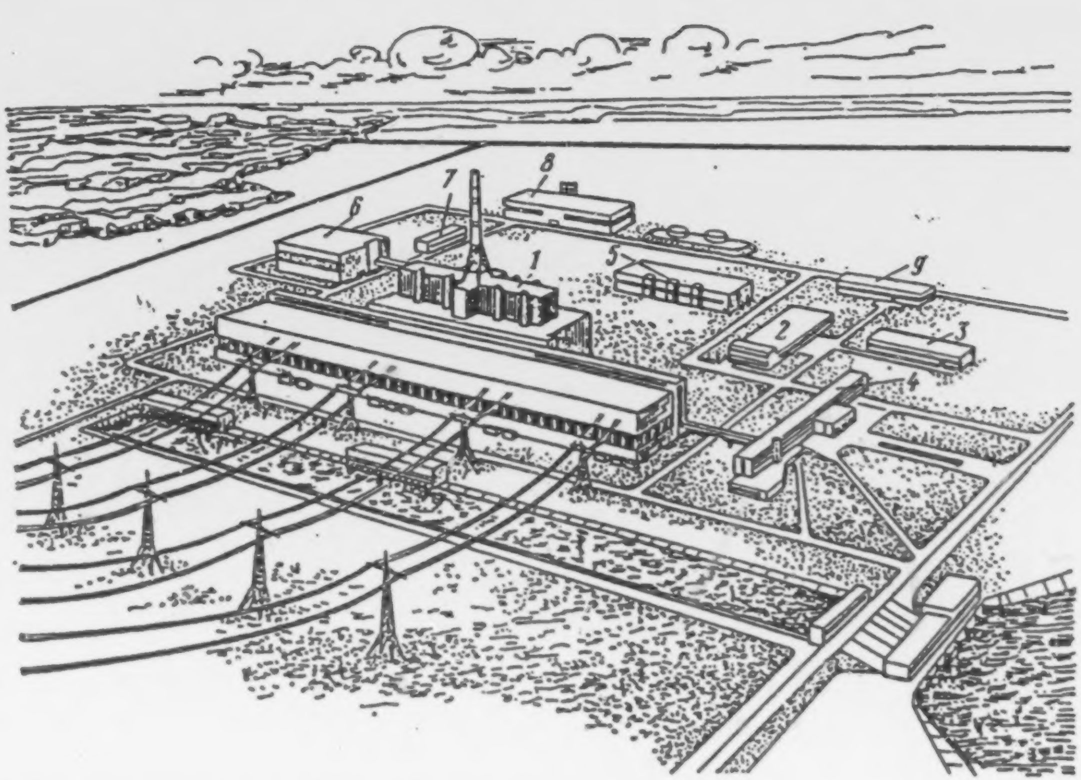
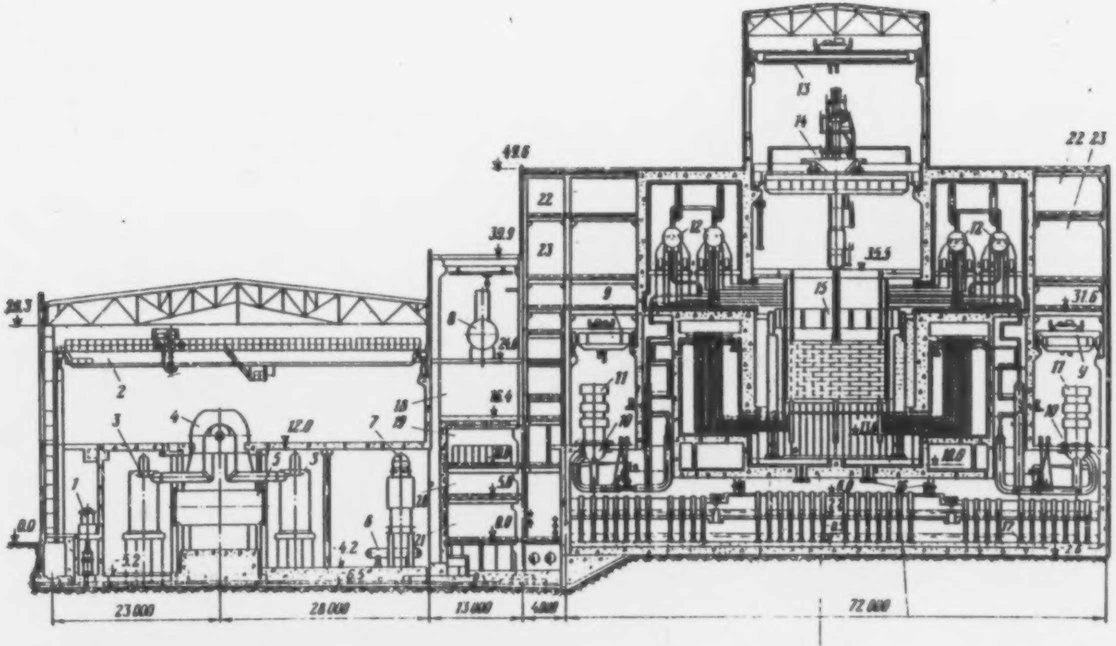


Fig. 3-12. General view of the Smolensk nuclear power plant

1—main building; 2—auxiliary building and chemical water clean-up building; 3—chemical storehouse; 4—administrative and welfare building; 5—Diesel-generator station; 6—liquid- and solid-waste storage facility; 7—nitrogen-oxygen station; 8—stand-by boiler; 9—new fuel storage facility



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12.0
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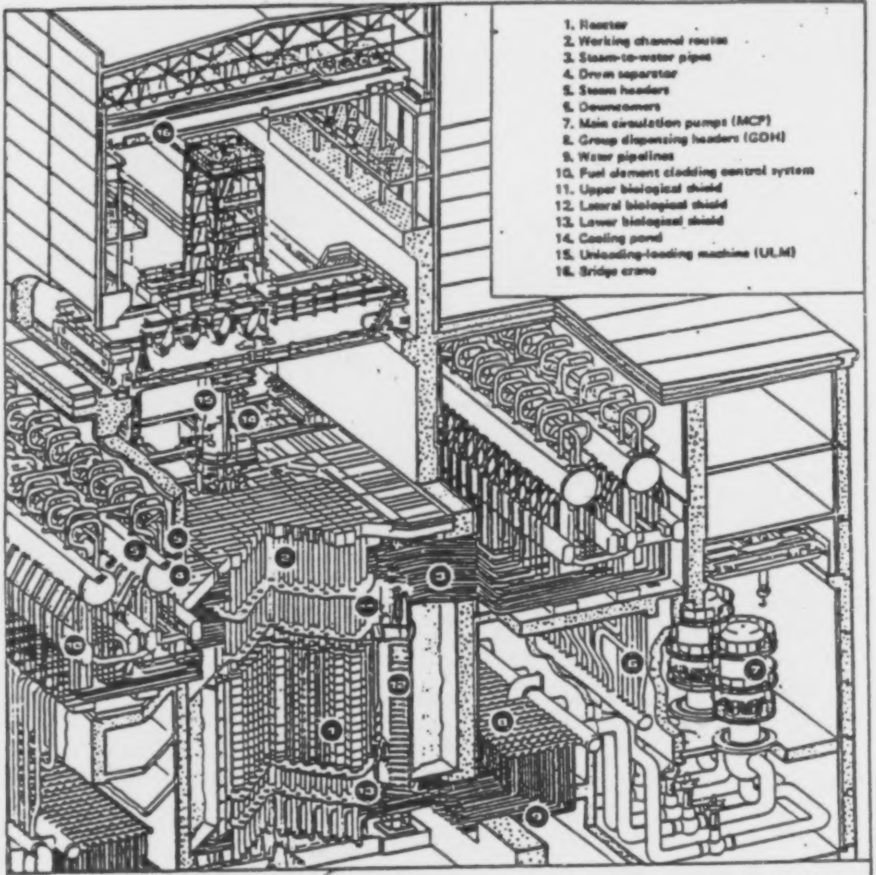
5.2
6.5
24.6
16.4
39.9
48.6
35.5
31.5
10.0
23000
28000
13000
4000
72000

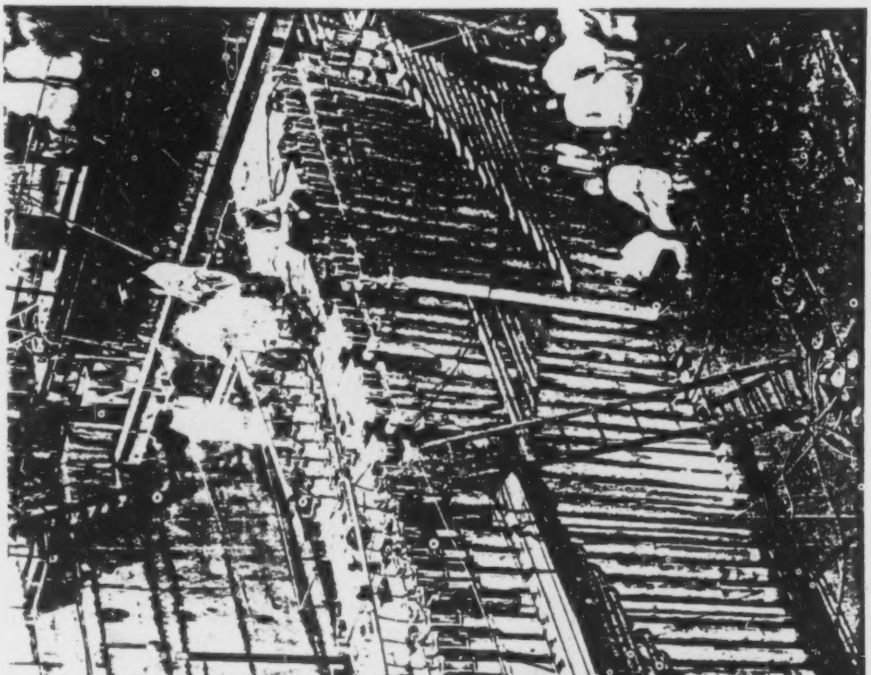
Fig. 3-13. Cross-sectional view of the main building at Smolensk

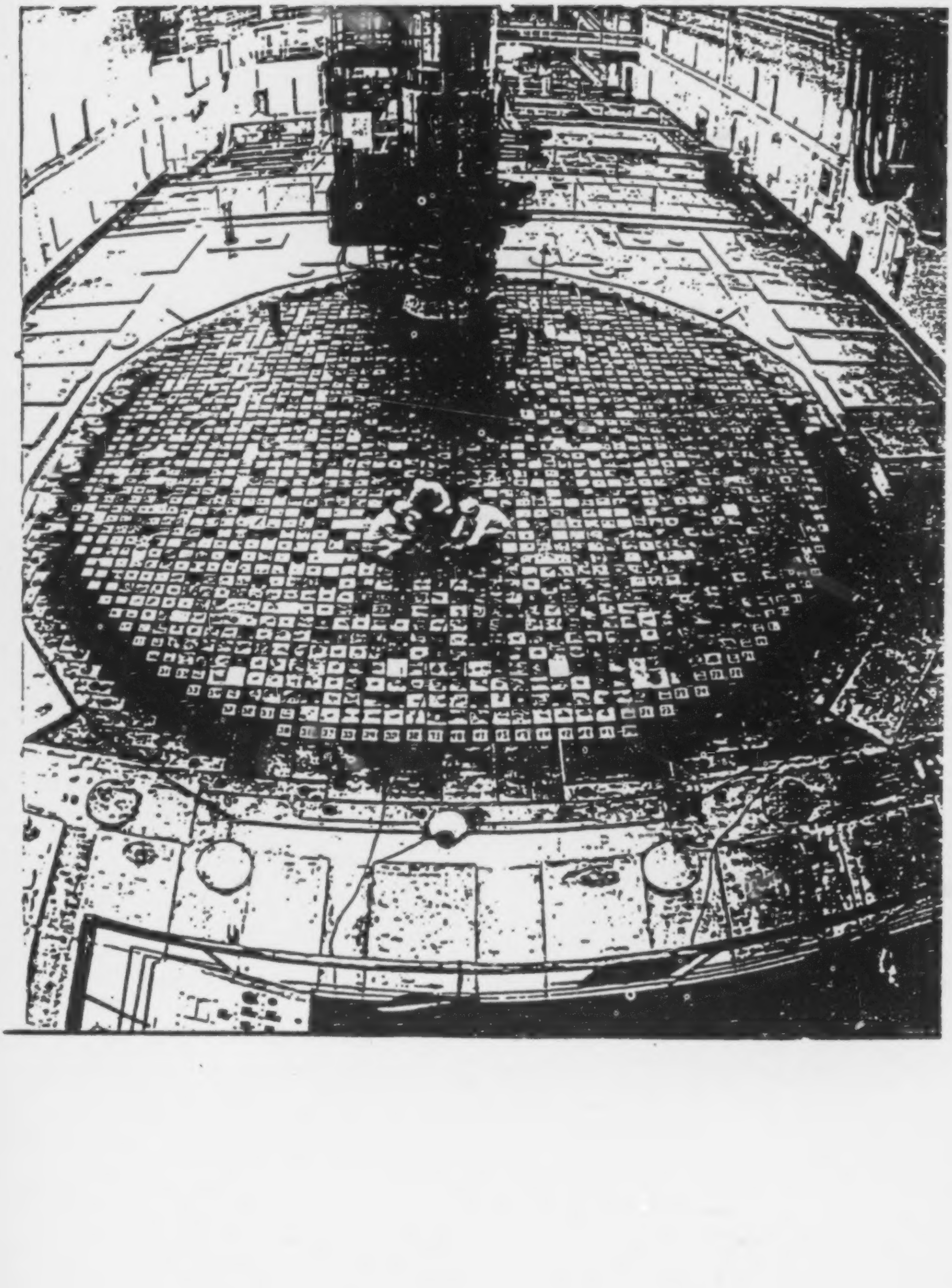
1—first-stage condensate pump; 2—125/20-t overhead travelling crane; 3—separator-steam superheater; 4—K-500-65/3000 steam turbine; 5—condenser; 6—additional cooler; 7—low-pressure heater; 8—deaerator; 9—50/10-t overhead travelling crane; 10—main circulating pump; 11—electric motor of main circulating pump; 12—drum separator; 13—50/10-t remotely controlled overhead travelling crane; 14—refueling mechanism; 15—RBMK-1000 reactor; 16—accident containment valves; 17—bubbler pond; 18—pipe aisle; 19—modular control board; 20—location beneath control board room; 21—house switchgear locations; 22—exhaust ventilation plant locations; 23—plenum ventilation plant locations

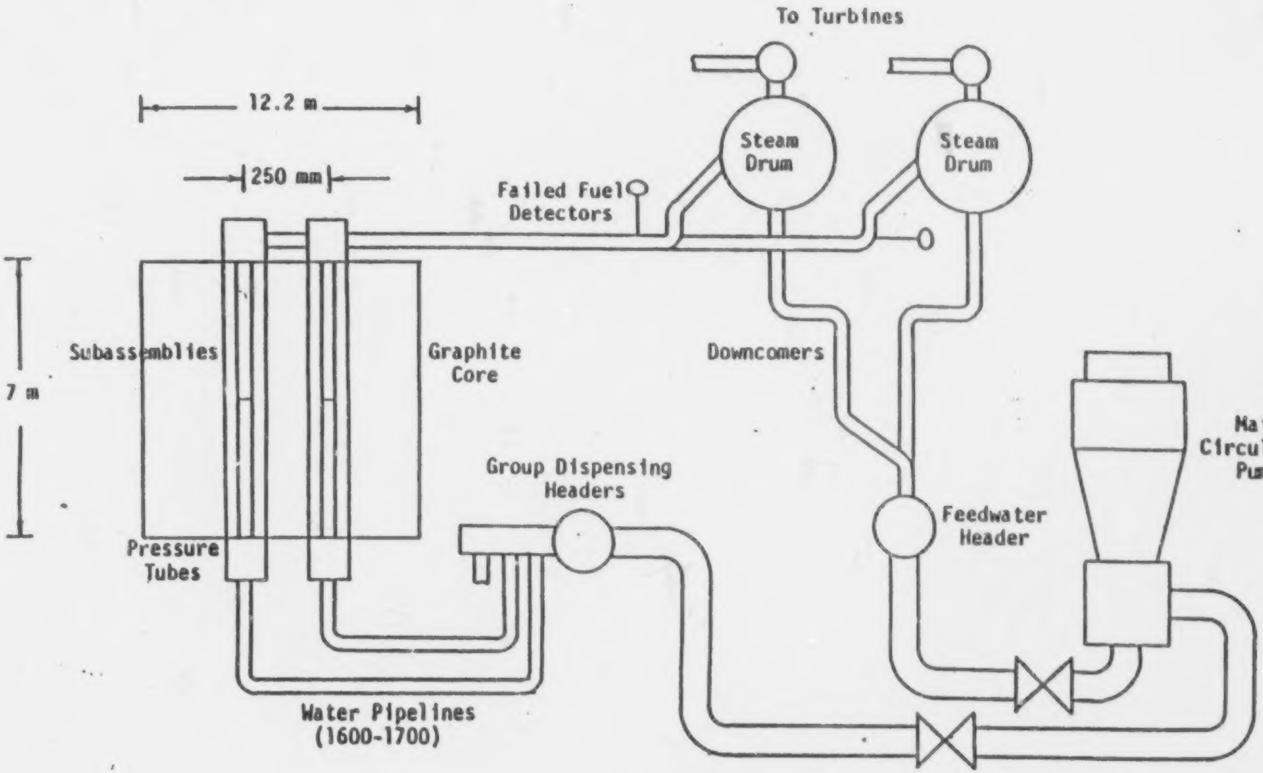

1. Reactor
2. Working channel routes
3. Steam-to-water pipes
4. Drum separator
5. Steam headers
6. Downcomers
7. Main circulation pumps (MCP)
8. Group dispensing headers (GDH)
9. Water pipelines
10. Fuel element cladding control system
11. Upper biological shield
12. Lateral biological shield
13. Lower biological shield
14. Cooling pond
15. Unloading-loading machine (ULM)
16. Bridge crane

A sectional view of the RBMK-1000 reactor. With an electrical power of 1000 MW, the reactor's thermal power is 3140 MW; the coolant flow is 37.5 X $10^3$ t/h and steam capacity 5.4 X $10^3$ t/h. The reactor inlet water temperature is 270°C and the saturated steam temperature 284°C with a pressure in the separator of 70 kg/$cm^2$. The initial fuel enrichment is 1.8%.

8






To Turbines
12.2 m
250 mm
Steam Drum
Steam Drum
Failed Fuel Detectors
7 m
Subassemblies
Graphite Core
Downcomers
Main Circulation Pump
Group Dispensing Headers
Feedwater Header
Pressure Tubes
Water Pipelines (1600-1700)

Schematic of an RBMK-1000 Generating Unit

## DESCRIPTION OF PRIMARY SYSTEM ENCLOSURE

## RBMK-1000

## ENCLOSURE PHILSOPHY

## DEDUCED FROM LITERATURE

o PRIMARY SYSTEM DOES NOT HAVE HOUSING EQUIVALENT TO A WESTERN STYLE CONTAINMENT

o ENCLOSES REACTOR AND MAJOR PIPING WITHIN MULTIPLE DRY WELLS

o PROVIDES A WETWELL BENEATH THE DRYWELL STRUCTURES

o ENCLOSES REMAINING PRIMARY SYSTEM WITH A CONFINEMENT STRUCTURE

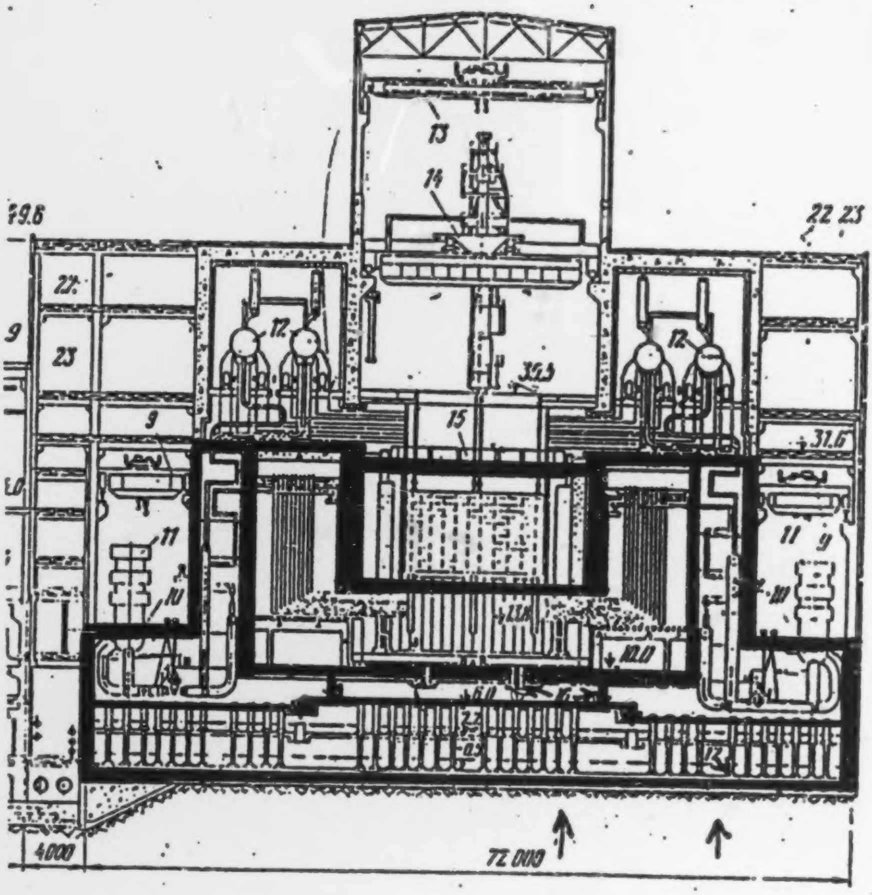
o METAL LINED RECTANGULAR VOLUMES

CURRENT CONCLUSIONS:

o WE DO NOT HAVE ENOUGH INFORMATION TO DRAW ANY DEFINITE CONCLUSIONS REGARDING THE CAPABILITIES OF THE PRIMARY SYSTEM ENCLOSURE

o IT APPEARS THAT THE SOVIET PHILOSOPHY OF CONTAINMENT/ CONFINEMENT IS SIGNIFICANTLY DIFFERENT FROM U.S./EUROPE

12


13
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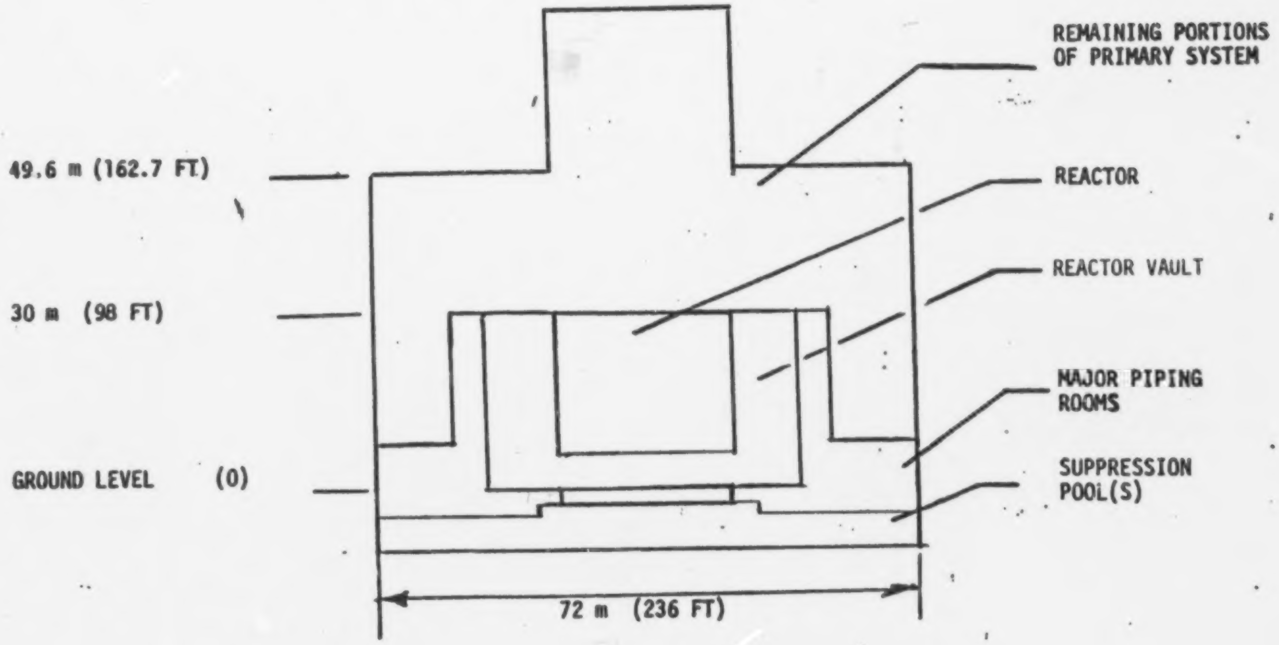
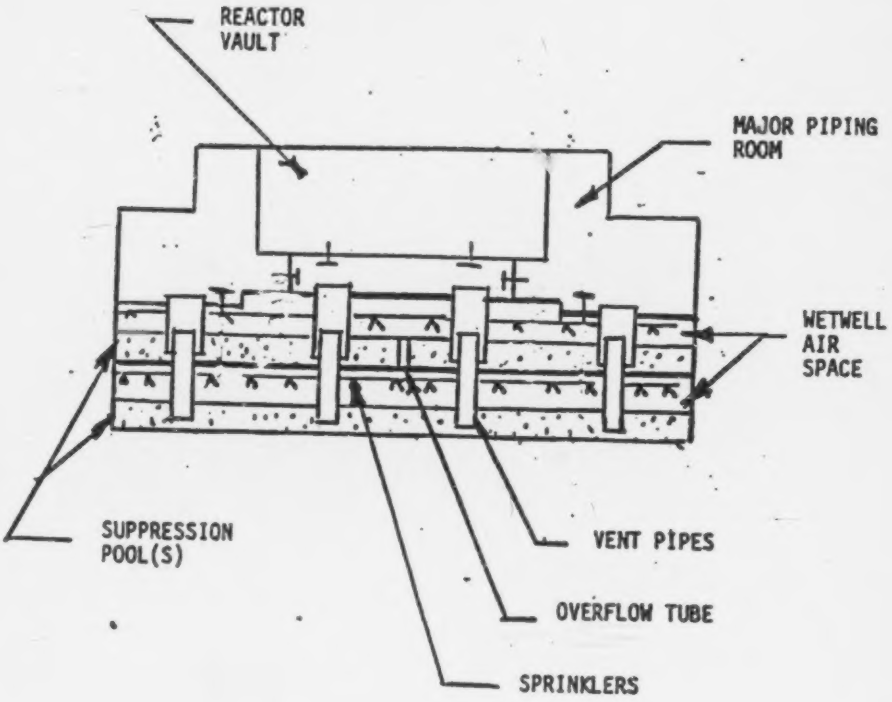
4000
72 000

PLANT ARRANGEMENT


49.6 m (162.7 FT)
30 m (98 FT)
GROUND LEVEL (0)
72 m (236 FT)
REMAINING PORTIONS OF PRIMARY SYSTEM
REACTOR
REACTOR VAULT
MAJOR PIPING ROOMS
SUPPRESSION POOL(S)

SUPPRESSION POOL

ARRANGEMENT


REACTOR VAULT
MAJOR PIPING ROOM
WETWELL AIR SPACE
SUPPRESSION POOL(S)
VENT PIPES
OVERFLOW TUBE
SPRINKLERS

## EVENT DESCRIPTION SUMMARY AND STATUS

- ON APRIL 26, 1986, AT APPROXIMATELY 1:23 AM, EXPLOSION(S) OCCURRED AT THE CHERNOBYL NUCLEAR POWER PLANT IN U.S.S.R.
- REACTOR HAD BEEN PREVIOUSLY OPERATING AT 7% POWER
- PRIMARY SYSTEM BOUNDARY FAILURE PROBABLY CAUSED BY OVERPRESSURIZATION DUE TO SUDDEN POWER INCREASE
- SUBSEQUENT HYDROGEN EXPLOSION(S) AND GRAPHITE FIRE
- DECAY HEAT PLUS HEAT FROM GRAPHITE FIRE PRODUCED TEMPERATURES SUFFICIENT TO MELT FUEL
- GRAPHITE FIRE HAS BURNED DOWN, SOME OR ALL OF MOLTEN CORE MATERIAL IS PROBABLY ON REACTOR CAVITY FLOOR
- CONCERN FOR MOLTEN CORE PENETRATION THRU SUPPRESSION POOL BASEMATS
- SOVIETS HAVE STATED THAT REACTOR IS STABILIZED AND ARE REPORTED FILLING SUPPRESSION POOL CAVITY WITH CONCRETE (WITH INTERNAL COOLING) AND INJECTING NITROGEN INTO CORE REGION
- THERE ARE MANY POSSIBLE SCENARIOS FOR CHERNOBYL THAT CAN LEAD TO THE DAMAGED CORE (BUT STILL DO NOT KNOW WHAT THE ACTUAL SEQUENCE OF EVENTS WAS)

## SOURCES OF ENVIRONMENTAL DATA

ELEVATED LEVELS OF RADIOACTIVITY DETECTED IN MORE THAN 10 COUNTRIES

SWEDEN AND FINLAND PROVIDED ACTIVITY MEASUREMENTS AS A
FUNCTION OF TIME BEGINNING SHORTLY AFTER THE ACCIDENT

## SOURCE TERM

- SOURCE TERM ESTIMATED BY EXTRAPOLATION OF ESTIMATED DOSE FROM CONCENTRATION MEASUREMENTS IN FINLAND AND SWEDEN BACK TO CHERNOBYL SITE

- ENERGETIC ATMOSPHERIC RELEASE

- AVAILABLE DATA INDICATE PROLONGED RELEASE

# EXTRAPOLATION FACTORS

## (BACK TO CHERNOBYL SITE)

ACCOUNT FOR:

- DISPERSAL IN AIR
- RADIOACTIVE DECAY
- CLOUD DEPLETION

VALUES FOR:

- EXPOSURE TO NOBLE GASES (1 E+5)
- INHALATION OF IODINES (1 E+6)

## ESTIMATED DOSES

| | LOCATION | DOSE,* REM<br>WHOLE BODY | THYROID |
|---|---|---|---|
| BASED ON MEASUREMENTS | STOCKHOLM<br>(750 MI) | 0.002 | 0.01 |
| BASED ON MEASUREMENTS | HELSINKI<br>(700 MI) | 0.005 | NO DATA |
| BASED ON MODELS | CHERNOBYL<br>(1 MI) | > 100 | 4000 |

*BASED ON 1-DAY EXPOSURE IN U.S.S.R.; 2-DAYS FOR SWEDEN AND FINLAND

## FUTURE PLANS

- PREPARE REPORT
- ISSUES
    - ° NEED FOR EARLY WARNING SYSTEM (IAEA)
    - ° NEED FOR SYSTEM FOR RAPID INTERNATIONAL DATA COLLECTION AND EXCHANGE (IAEA)
    - ° SEVERE ACCIDENT LESSONS
        - ACCIDENT RELATED ISSUES
        - SOURCE TERM TECHNOLOGY
- NO PROGRAMMATIC CHANGES BASED ON OUR PRESENT KNOWLEDGE AND UNDERSTANDING OF WHAT HAPPENED

The CHAIRMAN. Thank you, very much.

Ms. Mary Walker.

## STATEMENT OF MARY L. WALKER, ASSISTANT SECRETARY, ENVIRONMENT, SAFETY, AND HEALTH, DEPARTMENT OF ENERGY, ACCOMPANIED BY DON OFTE, PRINCIPLE DEPUTY ASSISTANT SECRETARY, DEFENSE PROGRAMS; MEL SIRES, ASSISTANT MANAGER, SAVANNAH RIVER OPERATIONS OFFICE; AND JOHN HUNTER, DIRECTOR OF NUCLEAR ENERGY AND SURPLUS FACILITY MANAGEMENT, RICHLAND OPERATIONS OFFICE

Ms. WALKER. Thank you, Mr. Chairman, members of the committee. I appreciate this opportunity to be here today to discuss the safety program at the Department of Energy.

As already indicated, Troy Wade, the manager of the Idaho Operations Office, and Del Bunch, the Acting Deputy Assistant Secretary for Reactor Deployment of the Office of Nuclear Energy are also offering testimony.

Accompanying the three of us are Donald Ofte, Principle Deputy Assistant Secretary, Defense Programs; John Hunter, director of nuclear energy and surplus facility management at Richland; and Mel Sires, the assistant manager of operations for Savannah River.

The nuclear disaster at Chernobyl understandably generates questions and a comparison of U.S. reactors, including those owned by the Department of Energy. This is particularly true since one of our reactors, the N-reactor at Richland, WA, is a graphite moderated system.

Before proceeding into more detailed issues, I would like to put in perspective the issue of safety, somewhat as the chairman has already reflected. Safety does not mean the absence of danger. There are no absolutes in complex systems. Safety and safe operations really mean the management of risk so that its existence is reduced to an acceptable level.

Though I would admit that the assessment of risk is not easy, and the comparison of risks are difficult, I would like to discuss today how the Department manages risks that are inherent in its operations, and in particular, its nuclear operations.

The Department is committed to operate its facilities so that the assumed risks are small, so that members of this committee and the public at large can have full confidence in our protection of the safety of our workers, the public and our environment. We are convinced that management is the fundamental aspect to ensuring the safe operation of our facilities.

Accordingly, DOE reactors are operated under a strong and effective safety program, which provides a multitiered approach to safety. This means a quality product, multiple layers of safety systems, actions to correct any anomalies that surface, continued safety upgrades, a widespread reporting of lessons learned so that others can profit from them, and an effective oversight in my office, and other places in the Department, to hold management accountable.

The Department's Nuclear Safety Program starts with the clear assignment of responsibility for safety, to DOE and contractor line managers, in both headquarters and in our field offices.

Independent safety oversight organizations at these levels assure that managers and employees fully adhere to safe practices. DOE has in effect a rapid, effective communications and emergency response capability to respond to emergencies at all nuclear facilities, and this clearly involves the public.

In September 1985, Secretary Herrington ordered a series of further initiatives to strengthen both the Environment, Safety and Health Organization within the Department, and assure an excellent safety record will be continued at the Department. These, of course, included a new assistant secretary, responsible solely for environment, safety and health and reporting to the Secretary, with no programmatic responsibility.

It also included technical safety appraisals that are in depth and multidisciplined appraisals of all of our high and moderate hazard nuclear facilities. These have already begun and have in fact been conducted at several of our facilities, including the N-reactor.

The technical safety appraisals cover organization and administration, operations, maintenance, training and certification, auxiliary systems, emergency readiness, technical support, security and safety interface, experimental activities, facilities safety review, nuclear criticality safety, radiological protection, personnel protection, and fire protection.

These actions, I might add, by Secretary Herrington, are in addition to the existing strong safety program at the Department.

For example, my office conducts about 100 safety appraisals per year at all levels; that is, management, contractor, and direct-facility appraisals.

The combination of good safety practices, a sharing of experience, effective independent review by environment, safety and health people, provides a basis for strength and confidence in the Department's system and the results, I believe, can be seen in our safety record, which has been excellent.

In response to the incident in the Soviet Union at Chernobyl, Secretary Herrington has taken additional steps. He has, in fact, accelerated the schedule for the technical safety appraisals of our major production reactors, including the N-reactor, and that, in fact, has been performed, and he asked my office to conduct two additional reviews of its reactor.

The first, a special safety review of the fire protection system and the graphite moderator, and the safety of the reactor's confinement system has been accomplished. The design review, which is I think fourth or fifth in a series of design reviews of the N-reactor, and is designed, itself, to be very comprehensive, is ongoing at this time and is expected to be completed in early July.

In addition to the reviews of my office, Secretary Herrington has asked certain independent experts to conduct an analysis and a review of the issues raised by the Soviet incident, in particular, with respect to the N-reactor and to provide him with their views.

This review has begun and is ongoing. He has also asked the National Academy of Science and the National Academy of Engineering to make an independent assessment of DOE's 11 major production and research reactors, again, including N-reactor.

We are confident that our ongoing safety program and these special reviews, conducted in light of the Soviet accident, will provide and do provide a strong foundation upon which we can with confidence reduce any inherent risks to a minimum, acceptable level, thus assuring our facilities are continued to be operated safely.

Obviously, further reviews must await more detailed information from the Soviet Government, but as that information is available, we will be analyzing it for lessons learned that can be applied to our safety program.

We believe at the Department that nuclear energy is a vital contributor to our security needs and our quality of life. It is an energy option that the Department believes can and should be preserved.

Based upon our own safety reviews, and the program in the Office of Environment, Safety and Health, I believe this can and is being accomplished in a safe manner, and we look forward to working with you in this effort.

Thank you.

[The prepared statement of Ms. Walker follows:]

STATEMENT OF

MARY L. WALKER

ASSISTANT SECRETARY FOR ENVIRONMENT, SAFETY AND HEALTH

U.S. DEPARTMENT OF ENERGY

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES

U.S. SENATE

JUNE 19, 1986

Mr. Chairman, thank you for the opportunity to testify before this Committee and the American public on the safety of the Department of Energy's research and production reactors. Accompanying me today are Troy Wade, Manager, Idaho Operations Office; Donald Ofte, Principal Deputy Assistant Secretary, Office of Defense Programs; Del Bunch, Acting Deputy Assistant Secretary for Reactor Deployment, Office of Nuclear Energy; John Hunter, Director, Nuclear Energy and Surplus Facility Management, Richland Operations Office; and Mel Sires, Assistant Manager for Operations, Savannah River Operations Office.

The nuclear disaster in Chernobyl understandably generates keen interest, questions, and comparisons of U.S. nuclear reactors, particularly those owned by DOE, with those in the Soviet Union. The reactors operated by DOE are critical to our national security and to our leadership in scientific and technical research. Therefore, I appreciate your invitation to testify to help in assuring you that the Department has and will continue to address nuclear safety as a matter of the highest priority.

## Emphasis on Safety

Before proceeding to more detailed issues, I would like to put the issue of safety in perspective.

Safety does not mean the absence of danger. Scientists and engineers will argue that there are no absolutes in dealing with complex systems. In 1903, Wilbur Wright wrote: "Carelessness and overconfidence are usually more dangerous than deliberately accepted risks." Therefore, it's appropriate for me to discuss with the Committee how the Department manages the risks that are inherent in all of its operations, and in particular, its nuclear operations. The Department is committed to operate our facilities to minimize and manage risks so that the public can have full confidence in our stewardship of the responsibilities we have to protect the safety of our workers, the public, and the environment.

The Kemeny Commission report to the President on the accident at Three Mile Island said:

> "After many years of operation of nuclear power plants, with no evidence that any member of the general public has been hurt, the belief that nuclear power plants are sufficiently safe grew into a conviction. One must recognize this to understand why many key steps that could have prevented the accident at Three Mile Island were not taken. The Commission is convinced that this attitude must be changed to one that says nuclear power is by its very nature potentially dangerous, and, therefore, one must continually question whether the safeguards already in place are sufficient to prevent major accidents."

One of Secretary Herrington's first actions over a year ago was to review the Department's health, safety and environmental programs and activities. This action was not the result of a crisis or a response to any perceived problems. The review conducted last year noted DOE's outstanding safety record. At the same time, the review indicated that authority for health, safety and environmental performance was dispersed. In response, the Secretary established the position of Assistant Secretary for Environment, Safety and Health reporting directly to him. Secretary Herrington recognizes that our mission to meet national security and scientific objectives carries with it a fundamental responsibility to assure worker and public health and safety and he has made it clear, throughout the Department, that discharging this responsibility is and will remain a top priority.

We are convinced that management is the fundamental aspect to insuring the safe operation of our facilities. The Department's nuclear safety program includes the clear assignment of responsibility and accountability for safety to DOE and contractor line managers in Headquarters and the field. In addition, independent safety oversight organizations at these levels assure that managers fully adhere to safety practices.

DOE reactors are operated under a multi-tiered approach to safety. This means: a quality product, multiple layers of safety systems, actions to correct any anomalies that do surface, and widespread reporting of lessons learned so that others can profit from them.

First, stringent requirements for safety pervade every aspect of the design, construction and operation of a nuclear reactor to assure quality.

Second, multiple lines of defense--defense in-depth--are provided to assure that potential equipment malfunctions or operator errors will not progress to an accident which endangers the public. These include:

- Redundant safety systems to prevent failures from causing harm to the reactor core.
- Redundant safety systems to prevent the release of dangerous quantities of radioactivity even if core damage should somehow occur.
- Independent oversight to assure that good safety practices are fully implemented.
- Effective emergency preparedness so that the public can be alerted and protected even in the unlikely event of a large accident.

Third, the United States nuclear community, of which the Department is a major member, has an unparalleled system for reporting, analyzing, and acting on equipment failures or operator errors. This is one reason why the Department is conducting a careful review of implications from the accident at the Chernobyl power plant.

One of the initiatives taken by the Secretary in 1985 was the establishment of Technical Safety Appraisals of all high and moderate hazard nuclear facilities. The Technical Safety Appraisals will review all aspects of safety, including organization and administration, operations, maintenance, training and certification, auxiliary systems, emergency readiness, technical support, security/safety interface, experimental activities, facility safety review, nuclear criticality safety, radiological protection, personnel protection, and fire protection. These DOE ES&H independent review teams are made up of technical experts from the Department, the Department's national laboratories, and private industry. Prior to the Chernobyl incident, we had scheduled Technical Safety Appraisals of our major production reactors including the N Reactor in Hanford, Washington, and four reactors at the Savannah River site in Aiken, South Carolina. In response to the Chernobyl accident, the Secretary directed that these schedules be accelerated. In addition, he requested that several special reviews be made of the N Reactor because it is the only one of the five that uses a graphite moderating system.

The status of the reviews by my office is as follows: A Special Safety Team has reviewed fire protection safety of the N Reactor's graphite moderator and the safety of the reactor's confinement system that is designed to ensure against an uncontrolled release of radioactivity. The Special Safety Team concluded that the graphite of N Reactor was well-protected from the damaging effects of postulated fires or explosions and that the confinement system meets federal requirements for protecting the public. Second, the Technical Safety Appraisal, one of Secretary Herrington's ES&H initiatives, has been completed. Their report is now being prepared. Third, a separate Design Review Team is now performing a detailed review of the N Reactor. We are confident that these reviews will fully assess the adequacy of the N Reactor design, management, and operating procedures. It is this combination of good safety practices, sharing of experience and meticulous review by independent experts that has been in the past and continues to be the strength of the Department's system.

At the Department's Savannah River Plant, we have recently completed a Nuclear Safety Program Appraisal and Management Appraisal. This review included safety management, reactor safety, radiation protection, emergency preparedness, and quality assurance. The Savannah River Operations Office and the operating contractor were judged to have effective safety, health, and quality assurance programs. The Technical Safety Appraisal of the Savannah River reactors will be started in July.

In addition to the internal series of safety reviews noted above, Secretary Herrington has also asked for several outside experts to review the safety of the N Reactor, in light of the Chernobyl incident. He has also asked the National Academy of Sciences and the National Academy of Engineering to make an independent assessment DOE's 11 major production and research reactors, including N Reactor.

The priority the Department places on its safety and health program is demonstrated by the positive results realized from that program and by the Department's excellent safety record. Without exception, for each year since its creation, the Department has carried out its operational missions with a safety and health record that is at least two-to-three times better with respect to fatalities, injuries, and illnesses than that of the private sector. DOE has safely operated its reactors for over 40 years. The quality of U.S. nuclear technology and its record are in no way diminished by the accident at Chernobyl. While we remain open to learning the lessons from this unfortunate incident, we believe the system we have in place is consistent with the Kemeny Commission's recommended attitude of "continually questioning" the significance of the safeguards we have in place.

Conclusion

The Department of Energy research and production reactors and the civilian U.S. nuclear power industry have an excellent history of safety. While we clearly must learn all we can about the Chernobyl accident and apply any appropriate lessons, this process must be deliberate and reasoned and any appropriate actions must be taken judiciously. The quality of U.S. nuclear technology and its safety record are in no way diminished by the accident at Chernobyl. The Department, in its commitment to continuously improve the safety of its facilities, will, as information becomes available on the Chernobyl incident, examine its facilities for possible improvements.

This concludes my prepared statement. We would be pleased to answer any questions you may have.

The **Chairman**. Thank you.

Mr. Wade.

Senator **Hecht**. Mr. Chairman, may I just say one thing before Mr. Wade begins?

The **Chairman**. Surely.

Senator **Hecht**. He is a Nevada man who I have known for many, many years. We have only loaned him to you in Idaho, but he epitomizes so much of dedicated, brilliant, hardworking Department of Energy officials, and he has devoted his entire life to this. I think when people have such dedication, that they should be acknowledged, and I just want to bring that out for the record.

The **Chairman**. Very good. I appreciate your willingness to loan him to us.

Senator **Hecht**. It is only short term; we need him back.

The **Chairman**. Mr. Wade, with that preamble.

## STATEMENT OF TROY E. WADE II, MANAGER, IDAHO OPERATIONS OFFICE, DEPARTMENT OF ENERGY

Mr. **Wade**. Mr. Chairman, members, and Senator Hecht, thank you, very much. It is my pleasure to be here today representing the Idaho National Engineering Laboratory, which has long been the location for much of this Nation's research in light water reactor safety, and also has been the location for the development and testing of many other reactors, some 52 reactors have been built and tested at the Idaho Lab over the years of its existence.

I will speak very briefly about past and current safety research and then my views on the likely influence of the Chernobyl accident on future research and development priorities.

I would like to begin by commenting on the outstanding safety record of the U.S. nuclear power industry, largely made possible by research into reactor and reactor materials behavior. Much of that research has been done at the INEL in reactors there, such as the materials test reactor, the engineering test reactor and the advance test reactor.

Those early experiments were followed by extensive safety research into severe accidents in both water cooled and liquid metal reactors. The activities at our laboratory encompass by experimental research and the development of a wide range of safety analysis tools and capabilities.

The three focal points for the INEL water reactor work, were reactor called Semiscale, the loss-of-fluid test facility and the power burst facility.

Semiscale is an electrically heated reactor in which thermal-hydraulic phenonema is investigated. The LOFT reactor is a liquid water reactor in which we have conducted some 40 nuclear tests to investigate reactor system behavior and the capabilities of the emergency core cooling system. In the power burst facility, we have taken various kinds of fuel, taken them to meltdown, measured the fission product release, and then measured those results against such things as the Three Mile Island accident.

The DOE and the INEL have been involved since the first day of the accident at the accident at TMI-2. Substantial release of fission products occurred there. We believe that a very significant portion of the reactor core melted. Unlike, however, the Chernobyl incident, the amount of fission products released from the TMI-2 reactor to the environment posed no significant threat to the public.

The scenario for the progression of the TMI accident would indicate that the relocation of the core into a reactor lower plenum that remains full of water will probably result in coolable debris which will arrest the accident. The reactor primary vessel integrity was maintained there. We believe it would be maintained in a similar accident, and as I mentioned, that information from TMI correlated very well with the experimental work done on the reactors LOFT and PBF.

Each of the facilities and test programs have contributed to the safety and to the information base from which the adequacy of commercial reactor designs and their safety and regulatory criteria are confirmed.

Many of the reactor codes that the Nuclear Regulatory Commission uses for licensing commercial power reactors are based on experimental data and analysis done by the Department of Energy.

The eventual impact of Chernobyl on existing light water reactors is difficult to assess. I believe that as was the case with TMI-2, as more information is available from the Chernobyl accident, we will begin to refocus the U.S. program. I do not see significant refocusing. I believe that we will continue the work on the program, such as severe accident phenomena, particularly as it might relate to containment response; we will continue to work on the resolution of the fission product release and source-term issue; and we will continue to minimize the human factor in reactor operations and control room designs.

I believe the Chernobyl accident will ultimately confirm the quality of U.S. safety technology. I am confident that the vast experience and expertise available at the DOE National Laboratories will contribute to the understanding and resolution of concerns raised by the accident at the Chernobyl plant.

We are continuing to work on advanced reactor safety at the INEL. We recently did a test on the liquid metal reactor called EBR-2 in which a loss of coolant, without reactor scram, provided for the automatic shutdown of the reactor. We continue to work with the Gas-Cool Reactor Association on their inherently safe designs.

I therefore see that many of these inherently safe reactor designs will receive a high priority. It is imperative that the safety of these next generation reactors be supported by tests and we have a program to do that.

Internationally, I believe it is important that the United States continue its involvement in IAEA and other international efforts so that we may fully understand the effects of the Chernobyl accident and that can indeed be inputed into the U.S. designs and research and development.

That concludes my summary, Mr. Chairman. Thank you for the opportunity.

[The prepared statement of Mr. Wade follows:]

STATEMENT OF

TROY E. WADE, II

IDAHO OPERATIONS OFFICE MANAGER

DEPARTMENT OF ENERGY

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES

UNITED STATES SENATE

JUNE 19, 1986

## Introduction

As a member of the senior management of the Department of Energy (DOE) and Director of the Idaho National Engineering Laboratory (INEL), I appreciate the opportunity to address the Committee today. As you know, the INEL has long been preeminent in the field of Light Water Reactor (LWR) research and analysis; in addition, INEL has been the location for the development and testing of many other reactor types. Breeder reactor technology was pioneered at INEL under the guidance of the Argonne National Laboratory, (ANL).

It is this extensive INEL technical background I bring to bear on today's concern. I have been asked to present the position of the DOE regarding the effect the Chernobyl accident may have on the research and development activities of both light water reactors and other advanced reactor types. I will begin by addressing the importance of past and current safety research activities in ensuring safe designs and the safe operation of U.S. reactors. Then I will speak to the likely influence of the Chernobyl accident on future DOE reactor research and development priorities.

## Importance of Past Safety Research

The generally smooth day-to-day operations and the outstanding safety record of the U.S. nuclear power industry is made possible by research into reactor and reactor materials behavior. The behavior of reactor materials and fuels in the high radiation environment in a nuclear reactor has been well-researched in DOE test reactors, such as INEL's Materials Testing Reactor (MTR), Engineering Test Reactor (ETR), and Advanced Test Reactor (ATR).

The transient kinetic behavior of light water reactors was studied at the SPERT-I through -IV reactors and liquid metal cooled reactor behavior was researched at EBR-I. At the INEL, liquid metal cooled reactor behavior and materials research continues at the EBR-II, and TREAT facilities.

The early experiments in basic reactor behavior and materials research were followed by extensive safety research at the INEL for severe accident in both water cooled liquid metal cooled reactors. INEL activities encompassed both experimental research and the development of a wide range of safety analysis tools and capabilities. The three focal points for INEL water reactor accident experimental research were the Semiscale Facility, the Loss-of-Fluid Test (LOFT) Facility and the Power Burst Facility (PBF).

Since it began operation in 1965, the Semiscale Facility has conducted hundreds of non-nuclear experiments to investigate thermal-hydraulic phenomena that occur in pressurized water reactors under abnormal conditions. The LOFT reactor began operation in 1976, and has conducted 40 nuclear tests to investigate reactor system behavior and the capabilities of emergency core cooling systems to prevent core damage during various reactor plant accidents including complete loss-of-coolant accidents. The LOFT test program culminated in two experiments in which the reactor fuel was allowed to reach temperatures sufficient to cause fuel failure and the release and transport of fission produces in the reactor system. Finally, since its beginning in 1972, the Power Burst Facility has provided detailed information on a variety of fuel types to better understand the behavior of fuel and the release of fission products during severe accident conditions. Experiments in the Sodium Loop Safety Facility installed in the ETR, answered many of the "what-if" questions concerning fuel behavior during severe accidents in a liquid metal cooled reactor.

The DOE and INEL are involved in the assessment of the severely damaged core in the TMI-2 reactor. This assessment has determined that the TMI-2 accident resulted in a significant amount of fuel melting; approximately 50 percent of the core was molten at some time during the course of the accident. Therefore, a substantial release of fission products occurred. But, unlike the Chernobyl accident, the amount of fission products released from the TMI-2 reactor to the environment posed no significant threat to the public. The scenario for the progression of the accident would indicate that the relocation of a molten core into a reactor lower plenum that remains full of water will probably result in coolable debris which will arrest the accident progression. Thus, the reactor primary vessel integrity is maintained. The understanding of severe accidents and source term phenomena from this work correlates with the results of small-scale tests such as those conducted at PBF.

Each of the facilities and test programs I have just described has contributed to an information base from which the adequacy of commercial reactor designs and their safety and regulatory criteria are confirmed. This data base is also instrumental in the development and verification of computer codes used to predict reactor plant response during reactor accidents. Thus, DOE supported reactor materials, behavior, and safety research have built and continue to build the foundations for safe and reliable nuclear power plant design and operation.

## Impact on Current Reactors

Although there is little similarity between Chernobyl Unit 4 and existing U.S. commercial reactors, and little is known about the Chernobyl accident, the accident has understandably generated considerable interest and concern in this country and world-wide.

The eventual impact of Chernobyl on existing light water reactors is difficult to assess. However, I expect that, as was the case with the TMI-2 accident, we will begin to collect all available information on the accident and factor the applicable lesson learned into the licensing and safety assessment of current U.S. reactors. Because of significant differences in the design and operation of U.S. reactors and the Chernobyl reactor, I believe that the Chernobyl accident will not cause significant refocusing of the U.S. reactor research programs. Research topics likely to be re-evaluated or to receive greater emphasis are those concerning:

1. Severe accident phenomena, particularly as it might relate to containment response.

2. Resolution of the fission product release source-term issue, and

3. Minimizing the human factor in reactor operations and control room designs.

While each of these areas are part of the ongoing U.S. reactor research program, lessons learned from the Chernobyl accident may lead to refocusing certain activities to expedite resolution of key issues. For example, the Chernobyl accident may provide insight into one of the most severe, low probability, core melt scenarios in which molten core material breaches the pressure vessel and contacts the concrete base in an already failed containment building. Some U.S. researchers feel that this scenario could release more of the low volatility rare earth, refactory, and transuranic activity than has been considered in any of our risk assessments. Availability of data concerning this scenario and its consequences will fill in the data set for source term research.

I believe the Chernobyl accident will ultimately confirm the quality of U.S nuclear safety technology. I am confident that the vast experience and expertise available at the DOE national laboratories will contribute to the understanding and resolution of concerns raised by the accident at the Chernobyl Nuclear Plant.

## Impact on Future U.S. Reactor R&D

The next item I would like to discuss involves the possible impact of the Chernobyl accident on the future direction of the DOE reactor research and development program. I would emphasize that, since definitive technical information regarding this accident is sparse, my opinions cannot be considered as final and complete at this time.

In making the following remarks, I am starting from the unaltered position that nuclear power will continue as an important energy source for the U.S. in the future. It is also a basic premise that public perception regarding the safety of nuclear reactors is an important factor in the continued and increasing utilization of this technology. The Chernobyl accident reinforces the need for continued priority emphasis on nuclear reactor safety in order that nuclear power will be significant and publicly supported source of electrical energy generation.

The primary effect of the Chernobyl accident on future DOE nuclear power R&D will likely be a reinforcement of the directions already being taken to explore the feasibility of "self-protecting" or "walk-away" safe designs for the future reactors. The operating history of current U.S. nuclear power plants shows that these plants can and do operate reliably and safely; but future design power plants should incorporate features to permit reduction in the multiplicity of safety systems and operating concerns required for such operation can be significantly reduced. Such simplification has the potential for further reducing accident probabilities and may tend to lower construction and operating costs.

A recent experiment for a loss-of-coolant flow without reactor scram or automatic shutdown at the EBR-II at INEL demonstrated the self-protecting nature of the pool-type of liquid metal cooled reactors, one of the reactor types now being supported by DOE for "next generation" nuclear power plants. The Modular High Temperature Gas-cooled Reactor (MHTGR) design supported by DOE and advocated by Gas-Cooled Reactor Associates (GCRA), a utility group, promises to be able to demonstrate a self-protecting nature. The Electric Power Research Institute and the DOE, including the Advanced Reactor Severe Accident Technology Program at the INEL, are supporting the development of design requirements and licensing criteria for "next generation" light water cooled reactors with an emphasis on simplified design and self-protecting characteristics.

"Next generation" reactor conceptual design studies for liquid metal and gas cooled reactors are including containment requirements that are less demanding than the requirements for current water cooled power reactors because of the self-protecting characteristics of these concepts and the significantly reduced probabilities for fission product releases. The Chernobyl accident should motivate a careful reexamination of containment requirements for "next generation" reactor designs.

I therefore foresee that these more inherently safe reactor designs will receive a higher priority in the future. It will be imperative that the safety of these next generation reactors be supported by tests. Therefore, a program will evolve to select a preferred reactor concept based on the criteria of economics, safety, reliability, and licensability.

## International Safety Research

Increased international coordination of nuclear reactor safety issues should be an important effect of the Chernobyl accident This unfortunate accident could provide a wealth of real data relative to worst-case accident radiological release, transport, environmental contamination and decontamination, accident recovery, emergency actions, and health effects that will never be available form our safety research programs. Therefore, it is important that the U.S. be involved in IAEA and other international efforts to fully understand and evaluate the Chernobyl accident.

Thank you for this opportunity to address this Committee.

The CHAIRMAN. Thank you.
Dr. Bunch.

## STATEMENT OF DR. DELBERT F. BUNCH, ACTING DEPUTY ASSISTANT SECRETARY, REACTOR DEPLOYMENT, DEPARTMENT OF ENERGY

Dr. BUNCH. Thank you, Mr. Chairman. I have three points I would like to make and I will briefly describe each of them.

First, the reactor at Chernobyl had what I consider to be inherently undesirable safety characteristics. We are now 2 months into that accident; as Mr. Denton has described we have gone to a great deal of trouble to understand what the Soviets have said about that plant, and what the technical literature says. We continue to work with the international community to obtain a better understanding of that plant, but it is important to recognize at this point what we believe to be the situation about that plant.

Second, a point I will also discuss in a little more detail, I think there has been a situation in which too many people are rushing to judgment about the implications of Chernobyl on the safety of the U.S. plants.

The third point is not one of safety, but, as you have discussed this morning in the colloquy, one of restoring or achieving public confidence in the safety that we do have. I think your committee's efforts to secure legislative reform of a new licensing process would be a great step toward that direction.

Back to the first point. I think the reactor at Chernobyl has undesirable safety characteristics. First, the nuclear properties of the plant, as were alluded to by Mr. Denton, were what I would call unstable. Disturbances in the plant would cause unwanted changes in power which placed stress both on the operators and on the safety system.

The engineering details of the plant, how the plant was actually put together, have little of what we have come to expect in the U.S. approach toward defense indepth.

I think it is fair to say that the Soviets in the last decade or so have put a great deal of attention on instituting a new safety regime in their practices for the engineering of nuclear power plants in the Soviet Union. In my own view, it seems to be, at least with respect to Chernobyl, too little, too late.

What has been done was simply not enough to overcome those intrinsic safety features in the plant.

Second, it is my view that too many have rushed to judgment about the implications of Chernobyl.

I think my own view, as a member of the task force, was that we saw a certain measure of instinctive reaction on the part of the technical community immediately following the accident. There were those who are strong opponents of nuclear power who seem to say—see, I told you so. Those who were strongly in support of nuclear power very quickly moved to say Chernobyl would never happen here.

I think the arguments that Mr. Denton has just given about the steps that we are taking to try to understand, apply, and learn whatever we can and do so in a disciplined way, is the proper course of action.

I think that probably we could have done better if we had informed the public about the strengths and the weaknesses of the Chernobyl reactor so that they could make their own informed judgment on that.

Having said that, I think it is still necessary to say after a couple of months of reviewing that plant, that what we see in terms of the inherent characteristics of the plant are not the kind of characteristics that we expect to see and that we in fact see, in the U.S. plants.

In part, I believe, this is due to the fact that in the 1960's, when the introduction of nuclear power in this country was just getting underway, what is now the Nuclear Regulatory Commission, spent a great deal of effort trying to develop general design criteria that would assure that the basic configuration of powerplants in this country was fundamentally sound and not fundamentally flawed.

I think that the measures that have been alluded to by Mr. Denton show in good measure the efforts subsequent to developing general design criteria, to augment the inherent safety characteristics and overcome any weaknesses have been massive and I believe a successful ones.

Finally, on that same point, I think that the severity of the accident at Chernobyl, seems to have been caused by the way that the Chernobyl plant was neutronically created, that is, its inherent and engineered safety features, and not really due to any physical phenomenon that you would expect to find in each and every powerplant that uses nuclear technology.

That leaves me again to reiterate the third point: namely, I think the issue is, one, primarily of restoring confidence and finding ways to restore confidence, and finding yet more ways to show that we have a program that emphasizes safety. I think we are all concerned about finding ways to improve safety in a disciplined way, where it makes sense to do so.

But I think none of these programs, to improve protection against core meltdown accidents in this country, should be taken as an indictment against safety. Our plants are simply not like Chernobyl.

I would put in a point of concern, raised by Senator Metzenbaum, I think a legitimate concern. I think in order for us to rightfully claim that the licensing process puts safety first, Federal regulators must act, and more importantly they must be seen as acting by the public as requiring that the industry get on with the job of resolving safety issues. There simply, in my view, is no excuse for tolerating delays in obtaining industry proposals on how they would respond to safety issues and, then moving ahead, quickly, with action and rulings on those proposals.

A comment on what we seem to be learning about Chernobyl at this point: I think as probably was evident by my first two points, that the answer does not lie in placing yet more emphasis on emergency planning or on the source term. I think emergency planning is not an answer for safety. At best, it is a coherent system for responding to a situation where attempts to prevent accidents have simply failed.

The most important actions we can take are the ones that were highlighted by Harold Denton, to protect the public by preventing accidents, and do so by looking at all aspects of design, construction, operation, and management.

As Mr. Wade was pointing out, I think that the call for increased simplicity, improved reliability, and enhanced safety in advance reactors is timely. I think it is a goal of national importance.

These goals, however, for product improvement are no different than the design goals considered when the U.S. civilian reactor industry was getting underway.

What has changed, I think, is we have a clearer idea on how to accomplish these goals in economically attractive ways.

The last point is that we do need a regulatory process that will pave the way for the introduction of better reactors for the future. That process should give first priority to the proper functioning of the powerplant. It should be a process that is structured to assure safety issues are promptly and effectively resolved.

A modernized licensing process will provide the framework for maintaining the strong focus on safety that is needed to protect the interests of the investors, the ratepayers and the public at large.

Finally, a full and open process for ensuring that safety issues are resolved before construction is allowed to proceed awaits only legislative mandate. We urge your committee to take action on Senate bill 2073.

[The prepared statement of Dr. Bunch follows:]

# STATEMENT OF
# DELBERT F. BUNCH
# ACTING DEPUTY ASSISTANT SECRETARY FOR REACTOR DEPLOYMENT
# U.S. DEPARTMENT OF ENERGY
# BEFORE THE
# COMMITTEE ON ENERGY AND NATURAL RESOURCES
# U.S. SENATE

JUNE 19, 1986

Mr. Chairman, I am privileged to appear before you today to discuss the accident at Chernobyl and its implications for the civilian nuclear power industry.

Chernobyl is a global issue. U.S. scientists and engineers are working with many groups and international agencies to better understand what happened, how it happened, and how we all can learn from the consequences of that accident. Soviet officials have stated that they will provide an analysis of the causes and consequences of the accident to the International Atomic Energy Agency (IAEA). Soviet officials are scheduled to provide their analysis to the IAEA in late August and U.S. representatives will attend that presentation.

It has been nearly 2 months since the accident at the Chernobyl powerplant. In that time, we have all sought to find the implications of this accident and the impact it may have on the safe use of nuclear power here and abroad. The absence of detailed analytical data has not helped our judgments.

Nonetheless, I will try to recount some basic facts and provide preliminary observations. This is based on a review of Soviet literature and the statements made to date by Soviet scientists and government officials.

We know that the Soviet engineers and scientists have nearly two dozen of the large RBMK reactors like Chernobyl in operation or under construction. These machines are light water cooled, graphite moderated, pressure tube, boiling water reactors. They utilize on-line refueling while the reactor is operating.

We know that the RBMK design has inherently undesirable operating characteristics. Special computer control of the reactor is required to maintain safe operation.

We know that most of the new construction in the Soviet Union is what are called VVER-1000s--pressurized water reactors with containments, and not the RBMK reactors like Chernobyl.

We know that the Canadians built and dismantled a pressure tube reactor--Gentilly-1--that had design and safety features that were similar to Chernobyl, but used heavy water as a moderator. Problems were encountered in safely controlling the Gentilly reactor and it was taken out of service.

We know that the United Kingdom considered use of the Soviet reactor concept, but abandoned that notion, largely because of safety concerns.

## What we know about the Chernobyl accident

We know that the accident that caused damage to the reactor also breached whatever pressure suppression or "containment" might have been present.

We know that an initial non-nuclear explosion knocked down the walls and opened the industrial-style building over the reactor cover. This explosion and the subsequent fire in the graphite caused a massive release of radioactive gases and particles into the environment. We suspect that the severity of the accident is directly attributable to the truly unique features of the Soviet design.

It should be recognized that the Soviet Union has made efforts to upgrade the safety of their new reactors. The Soviet Union has actively participated in the IAEA nuclear safety standards program and now maintains that these safety standards are the basis of its nuclear regulation. In 1983, a new State Committee for supervision of the operation of the Soviet nuclear power industry--effectively an independent regulatory body--was established. This has come too late to have influenced the basic design and safety philosophy of the Chernobyl reactors.

The Soviet claims about the safety of their products, before the accident at Chernobyl, are bound to have an impact on the credibility of claims about the safety of U.S. plants. Some will argue that nuclear power is not being safely controlled and perhaps can never be made safe enough.

The lack of full public confidence in our claims of safety is the most serious problem facing the nuclear industry today.

I doubt if I can today convert everyone to my views on this subject. Rather, I intend to retrace the path from past to present and, in so doing, identify some guidelines for reestablishing confidence in the nuclear option for the United States.

## The 1954 licensing legislation included a mandate to assure safety

The American Government showed great vision in 1954 when it enacted the "Atoms for Peace" legislation, the Atomic Energy Act. The landmark legislation of 1954 allowed and encouraged the use of nuclear technology here and abroad. It had two main goals--to help strengthen America's energy security and to help maintain U.S. technical leadership. A legislative framework was established that allowed these goals to be achieved.

The protection of public health and safety was an integral part of the Atomic Energy Act. Whatever was done in the name of securing economic and strategic values for the public was not to be at the cost of new perils and was not to create a great risk to life.

Under that legislation, the industry is responsible for assuring that their use of nuclear power is safe. Federal regulators are responsible for setting basic safety standards used by the industry. Having set the rules of the road, the role of regulation is to make sure that no segment of the industry cuts corners on safety in order to save money.

## Basic structure of the licensing process determines how the Act is implemented

The provisions of the Atomic Energy Act have been carried out through a "design-as-you-go", "regulate-as-you-go" licensing process. The real test of whether a plant is "safe" is faced after the plant is constructed. Moreover, with the regulator's willingness to put off issues for another day by naming things "unresolved" safety issues, operating licenses have been granted with many loose ends. This process was probably essential during the infancy of the nuclear era when the technology was immature, yet rapidly developing. It did facilitate the commercial introduction of an important new technology consistent with the primary goals of the Act to help strengthen America's energy security and to help maintain U.S. technical leadership.

However, one of the issues of the last decade has been whether the licensing process which allowed the public to secure the benefits of nuclear power did so in ways that adequately assured the public's confidence in nuclear powerplant safety. It is that issue which deserves thoughtful reassessment as your Committee considers the Administration's legislative framework for licensing new reactors.

Two problems must be kept in mind: first, a continued dissatisfaction with the regulator's ability to adequately deal with severe accident issues; the second, a seeming inability to resolve any safety issue quickly.

## All of our eggs are in the basket of core-melt prevention

The legislation granted broad safety powers to the Federal regulators. Very fundamental policy decisions had to be and were made.

The safety approach of Federal regulators has its origins in a policy adopted in the early 1960's. The policy allowing civilian reactors to be located relatively close to cities was called "engineering out the distance factor." The key to this safety approach was increased emphasis on assuring that equipment failures and operator errors would not turn into core meltdown accidents.

Plants did not have to show that systems were able to prevent a major release to the public even if a core meltdown were to occur. The pressures and temperatures associated with water escaping from a large pipe break set the basis for containment design. A core meltdown was called "incredible" and neither the regulators nor the industry was required to answer the question of "what happens if a core meltdown occurs."

General design criteria were subsequently issued that encouraged use of inherent characteristics in the reactor that would tend to maximize the ability of the powerplant to be self-correcting and minimize the consequences of equipment malfunction. The regulators also called for diversity and redundancy in the engineering of the plant to promote safety. These criteria have helped to assure that the inherent nuclear characteristics and the engineering of U.S. powerplants are fundamentally sound from a safety standpoint.

The core meltdown prevention policy adopted in the 1960's began to unravel at the edges in the 1970's. The 1975 Reactor Safety Study by the NRC Advisory Committee on Reactor Safeguards (WASH-1400/NUREG-75/014) and subsequent analyses included estimates of probabilities of core meltdown accidents far higher than the rules of thumb of one in a million or one in a hundred thousand used by the regulatory staff. On the other hand, technical analyses indicated that a core meltdown did not inevitably lead to immediate failure of containment and disastrous off-site consequences.

The March 1979 accident at Three Mile Island Unit 2 (TMI-2) showed, among other things, that the containment systems did provide an important measure of protection to the public, even with a core-melt accident. It also showed that some of the basic design features--such as small pressurizers--greatly complicated efforts to assure that core meltdown accidents would not happen again.

After TMI-2, actions were taken on a broad front to ensure that the probability of another TMI-2 was very, very small. This has been a costly but necessary outgrowth of our determination to correct weaknesses in design and operation.

Looking back with the hindsight of 20 years' experience, it is easy to see that the research and development community, designers, utilities, and regulators could have given greater emphasis to optimizing the inherent safety characteristics of proposed reactor design. Passing through the hurdles of a very burdensome regulatory process and dealing with repeated backfits would probably have been easier with a plant that had bigger safety margins and more fail-safe features. However, this is a lesson learned for new plants. The early application of general criteria helped to assure that the characteristics of today's reactors are fundamentally sound and not fundamentally flawed. The actions taken since TMI-2 should be viewed as an expression of the continuing commitment of the U.S. nuclear industry to prevent core-melt accidents through inherently safe nuclear characteristics and through the defense-in-depth engineering of the plant. The record of the civilian nuclear power industry amply demonstrates that positive steps have been taken to ensure that nuclear power remains a safe and reliable energy supply option for the United States.

## Why does it take so long to get anything done?

Unfortunately, it is difficult to convince the public that measures to assure safety have been totally effective. In part, this difficulty is due to the snail's pace with which technical issues are finally resolved. The credibility of events involving transients and failure of shutdown systems was debated some 20 years; plant changes are still not fully implemented. When compliance is delayed, there is concern that some accidents in some plants could turn out just like Chernobyl. In a licensing regime dependent on showing that accidents will not result in core meltdown, delays in resolving safety issues are intolerable--they allow design or operational weaknesses to continue and erode public confidence.

In order for us to rightfully claim that the licensing process puts safety first, Federal regulators must act and be perceived by the public as acting to require that the industry get on with the job of resolving outstanding safety issues. There is no excuse for tolerating delays in obtaining industry proposals for resolving generic issues and then ruling on those proposals. Anything less will further erode public trust and weaken the foundation for continued improvements in safety.

If regulators cannot assure the public that their strategy of core meltdown prevention works and is being effectively implemented, then it is time to revisit the licensing process and the regulatory management structure. We need a regulatory process that will assure that safety issues are promptly resolved.

## Emergency planning can be improved

Those who look to Chernobyl to find insights about emergency planning or source term issues are missing the point. It should be apparent to all that an accident that results in major core damage and early failure of containment will have disastrous off-site consequences. Chernobyl will teach us nothing new regarding that basic conclusion.

Emergency planning is not an answer for safety. It is at best a coherent system for responding to a situation where attempts to prevent accidents have failed. The most important actions we can take to protect the public are those calculated to assure the proper functioning of the powerplant, determined by design, construction, operation, and management.

The existing emergency planning requirements were developed as another add-on safety requirement that had little to do with the underlying safety of the technology. Evacuations are a response to a disastrous release of radioactivity. The public need not fear a disastrous release of radioactivity if the industry builds reactors whose inherent features assure a low probability of a core meltdown accident and there is a guarantee that unsafe levels of radioactivity will not be released into the environment even in the remote event where such quantities of radioactivity were to be released from the reactor itself.

Current requirements for emergency planning are detailed, prescriptive, and comprehensive. They require an unprecedented degree of coordination among diverse groups. We do not set priorities for assuring public safety nor do we clearly distinguish actions according to their ability to resolve important issues or to definitively assign responsibilities.

It is no wonder that we have nuclear powerplants hostage to situations and organizations outside their control--everyone's authority seems tied to someone else's action. We should not argue about who does what, but simply evaluate if what we are requiring adds significantly to the safety of the people we are all committed to protect.

The nature of radiological releases, not unreasonably, is that those nearer to the release are at the most risk. Priority should be placed on protecting the public most at risk. It would be most reasonable then to focus immediate decision-making, warning, and protective actions at the site and its immediate environs. This is what the NRC should concentrate on for licensing purposes and this is what the utility should focus on for crisis management purposes. State and local governments then would focus on sound strategies to minimize the threat to the public beyond the site area. A two-pronged crisis management strategy should emphasize (1) thoughtful decision-making on accident recovery measures within the plant and (2) focused or graded action to protect those most at risk. This two-pronged strategy would be far superior to the present system.

## The case for licensing reform

The pressing need to assure the public of the safety of our current plants fits squarely with reform proposals to resolve safety and design issues in advance of design and site approval for future plants. These key concepts now become more urgent after Chernobyl. Further, with adequate information, the public would have a full opportunity to be heard on any questions about a decision on approving a design for use in building a nuclear plant. Why should the public continue to feel safety issues are not being resolved when a process for doing so in advance and in a systematic way needs only legislative mandate?

We agree with Ellyn Weiss' statement last July before a House subcommittee on behalf of the Union of Concerned Scientists that:

> "...(E)limination of the current 'design as you go' system would do more to enhance safety and predictability than all the provisions combined which regularly come to Congress each year (on nuclear licensing reform)."

Further, if we want to ensure technical integrity and public confidence in our nuclear industry, we must have a well-defined management system to inspect and verify the quality and validity of plant construction. If the major safety issues are completely resolved in the design and siting, then the construction/operation license public hearing should focus on the specific application of the design to the site and the construction approval to the utility. At this point, the participants should have a clear idea of what benefits and risks that powerplant poses to society and what benefits and risks it doesn't. On that basis, a decision to build and operate a plant can be made conscientiously and responsibly. If an "approve-before-you-build" system is put into effect, we should have the confidence to allow operation without further litigation.

Finally, as new information leads to the need for modification(s), the Administration's licensing reform proposal reemphasizes that the point of regulation is increased plant safety. That is the standard against which we should measure our actions. It is the rationale for regulation in the first place. Anything less than achieving assured plant safety should be discarded.

As we look to the future, one key action is to show continued success in the operation of existing powerplants. In part, this will require that we confirm that the fission product control systems in our operating reactors are adequate for the task of protecting the health and safety of the public. If containment systems have to be upgraded to deal with core meltdown accidents, then let's get on with it. It is essential that we take those steps necessary to restore public confidence in plant safety.

As for new plants, our engineers and scientists are well on the way toward developing advanced power reactors--using water, helium, and sodium as coolants. We know how to build simpler, safer reactors, and the concepts on the drawing boards will provide the American public with reliable, economic, and safe power to meet our future needs. This hope for the future requires two actions. If the promise of enhanced safety in future reactors is to be realized, we must have a licensing process which will bring advanced reactors into use.

Senator McClure has introduced the Administration's legislative proposal that would modify the licensing process. We urge the Committee to take action on S. 2073. This legislation would require that the success of the core meltdown prevention strategy be fully considered and decided (with respect to a standardized design at a preapproved site) before construction is allowed to begin. We ought to be able to understand the safety strengths and eliminate the weakness of any future design before it is approved for widespread use as a standardized design.

A licensing process which puts a premium on resolving safety questions before construction begins should have a valuable side benefit. Concepts which have relatively greater inherent or passive safety should fare well under a restructured licensing process. All concepts would have to show that any major safety concern were resolved before construction of a powerplant based on that concept could begin. A plant like Chernobyl would never survive the kind of process contemplated in our proposed legislation; a reactor that exploits the best that the technology had to offer in preventing core melt accidents might well prove to be the only easily licensable concept.

There is no reason why safety and economics have to be sworn enemies. Chernobyl shows the danger of focusing on safety after the inherent features of the plant are already fixed. General design criteria, such as those issued in the 1960's, did much to assure that U.S. reactors were fundamentally sound--not fundamentally flawed. We can do better still. Work now underway on improved design criteria and advanced reactors holds great promise for the nuclear option. A modernized licensing process will provide the framework for maintaining the strong focus on safety that is needed to protect the interests of investors, the ratepayers, and the public at large.

Mr. Chairman, this completes my prepared statement. I would be pleased to answer any questions you or members of the Committee may have at this time.

The **Chairman**. Thank you. We will proceed on the first round of questions among the Senators. My first question is to Mr. Meyers. Are there any Federal plans in place that would activate an interagency task force, similar to the one that was convened after the Chernobyl incident, responding to any future nuclear plant accidents that might have national or transboundary consequences to the public?

Mr. **Meyers**. Do you mean a domestic accident, Senator?

The **Chairman**. Domestic or international.

Mr. **Meyers**. There is FEMA, that would take care of any accident that would happen domestically. We are trying to reconstruct—you may recall that the initial impetus for this task force being put together was a group that was to respond to an international nuclear detonation, and the people in the Executive Office of the President felt that the same kinds of services would be required to respond to the accident at Chernobyl.

We are looking at that memorandum of understanding to see if it can be broadened to accomplish the purposes that you are suggesting.

The **Chairman**. You are looking at it, but it is not yet in place?

Mr. **Meyers**. That is right.

The **Chairman**. Mr. Denton, could you explain to laymen, what is the difference between containment and confinement, in nuclear terms.

Mr. **Denton**. All U.S. plants have had since day 1 what we call a containment building. That goes all the way back to plants like Yankee and Dresden. Yankee was put in operation some 25 years ago. What they were intended to be was a strong enclosure which would contain the radioactive fission products that might be released in the event of reactor accident, with very minimal leakage.

A confinement building, in my use of the term, has been a building which didn't have these pressure retaining features, but would slow down the release and would perhaps result in a controlled release. The confinement building would permit the release of perhaps the noble gasses, but filters would be in place to filter iodides and particulate matter. In plants which might be so large that containments would be impractical, confinement buildings have been occasionally proposed.

But for the commercial plants—all plants, I would say, except for Fort St. Vrain in Colorado, have what I call a containment building. Fort St. Vrain is a gas-cooled graphite moderated plant. After Chernobyl, I did ask staff for a special study of the safety of that plant. We did look at it and concluded that it could continue operating. It has a number of different features. It has inert coolants, so it does not have water in it. It doesn't have zirconium because the fuel is interspersed in the graphite. There is an 8-foot thick reactor pressure vessel, prestressed, and it is surrounded by a confinement building. That is the only plant that does not have a containment building in commercial use.

The **Chairman**. If I recall, one of the problems that surfaced, one of the concerns that surfaced at TMI, there was a problem to the people who were trying to understand and manage that accident was the build-up of hydrogen. And if I recall reading the news reports with respect to Chernobyl, it is suspected, at least, if not confirmed, but at least suspected that the thing that breached the confinement, the suprastructure of the industrial building in which it was located was a hydrogen explosion. Is that correct?

Mr. DENTON. Let me answer the first question first. There was a hydrogen explosion in the TMI containment. Those containments were so big and so strong it did not threaten the integrity of the building.

Our present view on the Chernobyl accident is that probably the power surge which occurred ruptured some of those 1,700 pressure tubes—one or more of those tubes—and exposed a very thin wall enclosure of the core to direct reactor system pressure—1,000 pounds per square inside pressure. It was probably the steam pressure that caused the initial physical disruption of the core.

After that occurred, we think that the fuel overheated, the metal water reaction produced hydrogen and hydrogen probably did seep into several areas of the plant. It is thought that there was one or more explosions of hydrogen. Then, that caused further core disruption and that led to the graphite fire, and in effect, disrupted the industrial type enclosure that was around this reactor.

I don't consider that plant as having the type of containment building that we have in licensed plants in the United States.

The CHAIRMAN. Have we taken corrective action since TMI, dealing with the potential for a hydrogen build-up?

Mr. DENTON. Yes, sir. We have a rule that we adopted since TMI requiring that plants be able to cope with the generation of hydrogen. A great deal of research has been done at Idaho and other places in that area, and some of it is still going on. But we have provided all our plants a capability to withstand hydrogen, depending on the circumstances.

We think our plants can all stand accidents beyond the design basis, and some have the capability to withstand accidents that would be greater, beyond the design.

The CHAIRMAN. When TMI occurred, we immediately turned to research facilities in the United States to try to understand what was happening, to interpret data that we were getting at TMI. We turned to things like LOFT and PBF. Is that not correct?

Mr. DENTON. Yes, sir; that is correct. We also, you recall, took action to shut down similar, or plants of identical design following TMI. I suspended the operation of the other B&W plants for some time. I understand that in the Soviet Union, the other 15 or so plants that are identical to this design are continuing to operate.

The CHAIRMAN. How were LOFT and PBF used at the time of the TMI accident?

Mr. DENTON. They were used two ways. We attempted to have some conditions simulated right during the event. While I was at TMI, we were in communication with the reactor laboratory, attempting to use them to calculate what might happen next in the TMI core. So there was some immediate use made of their capabilities.

Then after that, we had a large program to be sure we understood the core, and Mr. Wade has mentioned a number of the tests that were done.

I was at TMI just yesterday observing the preparations for loading the first canister out of the core into the cast to be shipped to

Idaho, and that will give us further information on what actually happened during the accident and what isotopes do come out in the event of a severe accident.

Maybe Mr. Wade would like to elaborate on the types of tests that were done. But we have made substantial use of the Laboratory's capabilities since TMI.

I think our understanding now of what happens in a water reactor is much increased as a result of those efforts.

The CHAIRMAN. Mr. Wade, in terms of safety research facilities at DOE labs, do we have the same capability today that we had at the time of TMI in 1979?

Mr. WADE. No, we do not, Mr. Chairman. Some of the facilities that were available in 1979 have been shut down or put on standby. They reached the end of what had been their projected experimental programs. So, in fact, the LOFT reactor to which Mr. Denton referred, and the PBF reactor are at the present time not operating. They were at the time of the TMI accident.

The CHAIRMAN. Are those the only safety research facilities that have been put on standby or deactivated since 1979?

Mr. WADE. No, sir. There have been others. There are thermal hydraulic safety facilities that are jointly operated by the NRC and industry which are still operating. There is a facility that I referred to in my statement in Idaho called Semiscale, which is currently planned to shut down at the end of this fiscal year. There is a research reactor at Sandia in Albuquerque which continues to operate.

The CHAIRMAN. Of these that have been shut down, how many could be reactivated, if they were necessary in the future?

I assume that the ones that are on standby could be started up, again. If I am in error in that assumption, I wish you would state that, too.

Mr. WADE. Well, in Idaho, Mr. Chairman, of the three major test facilities, the PBF reactor could be restarted. The Semiscale facility could be continued. The LOFT reactor has been dismantled. It could not be restarted, but I believe that the data we got from the LOFT tests correlates very well with our understanding of what happened at TMI and we would not need to repeat those kind of tests, again, anyway.

Mr. DENTON. Mr. Chairman, I might like to add one further amplification. I realize this is not a budget meeting, but it bears on the topic. I think our expenditures on safety research have dropped dramatically over the past decade. In real dollars, we are probably spending one-fourth or one-fifth as much as we were spending at the time of TMI.

I do observe, worldwide, much of the leadership in safety research and development is moving outside the United States now because those countries seem to be developing new programs and building more plants. But, for whatever reason, we are increasingly have to go to other sources for our data. We do work through agencies like the Nuclear Energy Agency and the IAEA to try to determine what is being done worldwide so we can maximize the dollars that we do spend to be sure that we are not duplicating anything spent anywhere else in the world.

The **Chairman**. If we were to have another accident like TMI, would we go offshore for some of the research capability that we use to have inside this country?

Mr. **Denton**. The way the NRC works since we don't have any national laboratories, is that we develop a need for the information and we go to to the Department of Energy and say—can you provide this? If they don't have it, we would hope they would look offshore. But we tend to identify what our needs are and depend upon them to provide it.

The **Chairman**. Troy?

Mr. **Wade**. I think the fact is, Mr. Chairman, that we would have to go offshore. If we had a TMI kind of accident in the next week or so and had resources enough to restart some of our domestic test reactors, we could not do it in time to be of any help.

The **Chairman**. My time has expired.

Senator Wallop.

## STATEMENT OF HON. MALCOLM WALLOP, A U.S. SENATOR FROM THE STATE OF WYOMING

Senator **Wallop**. Thank you. I have an opening statement for the record which I would ask unanimous consent that it be inserted in its entirety.

The **Chairman**. It is so ordered.

[The prepared statement of Senator Wallop follows:]

STATEMENT BY SENATOR MALCOLM WALLOP FOR THE HEARING RECORD FOR THE HEARING BEFORE THE SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES ON THE CHERNOBYL ACCIDENT, JUNE 19, 1986, 9:30 A.M.

MR. CHAIRMAN, THERE IS A MYTH CIRCULATING IN OUR COUNTRY AND ABROAD THAT THE SOVIET UNION HAD NO WRITTEN OBLIGATION TO INFORM THE WORLD IMMEDIATELY OF THE CHERNOBYL NUCLEAR REACTOR ACCIDENT. THIS COMMITTEE HAS HEARD THAT MYTH REPEATED BY A STATE DEPARTMENT WITNESS WHO APPEARED BEFORE US IN A BRIEFING FOLLOWING THE ACCIDENT, BY FOREIGN EXPERTS AND BY THE NEWS MEDIA. WE HAVE HEARD THIS FACTOID REPEATED BY MANY RESPONSIBLE OFFICIALS OF THE INTERNATIONAL ATOMIC ENERGY AGENCY IN THE COURSE OF THEIR INTERVIEWS AND BRIEFINGS TO INFORM THE PUBLIC AND THE WORLD COMMUNITY ON THE DETAILS OF THE CHERNOBYL DISASTER.

THE FACT OF THE MATTER IS, MR. CHAIRMAN, THAT THE SOVIET UNION DID HAVE A WRITTEN INTERNATIONAL OBLIGATION TO INFORM THE WESTERN WORLD IMMEDIATELY OF THE CHERNOBYL ACCIDENT! THAT OBLIGATION IS ENSHRINED IN THE FINAL ACT OF HELSINKI OF THE CONFERENCE ON SECURITY AND COOPERATION IN EUROPE, SIGNED BY 35 NATIONS AT HELSINKI, FINLAND IN 1975.

IN THAT AGREEMENT, THE SOVIET UNION AGREED TO A SERIES OF MEASURES CONCERNING INTERNATIONAL ENVIRONMENTAL PROBLEMS. THERE ARE NO LESS THAN THREE ENTIRE PAGES OF THE HELSINKI FINAL ACT SETTING FORTH WHAT THE SOVIETS AGREED TO DO ABOUT ENVIRONMENTAL PROBLEMS SUCH AS THIS NUCLEAR REACTOR ACCIDENT. I WILL ASK, MR. CHAIRMAN, THAT THE TEXTS OF THOSE PAGES BE INSERTED IN THE RECORD AS PART OF MY STATEMENT BUT I WANT TO HIGHLIGHT FOR YOU THE MOST IMPORTANT POINTS. THE SOVIET UNION AGREED, INTER ALIA, THAT IT WOULD

"CONSULT ON VARIOUS ASPECTS OF ENVIRONMENTAL PROTECTION, ... ESPECIALLY IN CONNECTION WITH PROBLEMS WHICH COULD HAVE INTERNATIONAL CONSEQUENCES."

THE SOVIET UNION ALSO AGREED THAT IT WOULD DEVELOP FURTHER SUCH COOPERATION BY

"PROMOTING THE PROGRESSIVE DEVELOPMENT, CODIFICATION AND IMPLEMENTATION OF INTERNATIONAL LAW AS ONE MEANS OF PRESERVING AND ENHANCING THE HUMAN ENVIRONMENT, INCLUDING PRINCIPLES AND PRACTICES RELATING TO POLLUTION AND OTHER ENVIRONMENTAL DAMAGE CAUSED BY ACTIVITIES WITHIN THE JURISDICTION OR CONTROL OF THEIR STATE AFFECTING OTHER COUNTRIES AND REGIONS."

I THINK THE ENGLISH HERE SPEAKS FOR ITSELF AND COMMON SENSE TELLS ME THAT I DO NOT NEED A BEVY OF FANCY INTERNATIONAL LAWYERS TO INTERPRET THIS TO MEAN ANYTHING OTHER THAN THE FACT THAT THE SOVIET UNION AGREED, WITH 35 OTHER NATIONS WAY BACK IN 1975, TO PROVIDE TIMELY INTERNATIONAL INFORMATION OF AN EVENT SUCH AS THE CHERNOBYL ACCIDENT. THE FACT THAT THEY DIDN'T DO IT IS ONE MORE EXAMPLE, MR. CHAIRMAN, OF THE CYNICAL AND IMMORAL WAY THE SOVIET EMPIRE HANDLES ITS WRITTEN AGREEMENTS WITH THE WEST, FROM HUMAN RIGHTS TO ARMS CONTROL TO THE ENVIRONMENT.

MR. CHAIRMAN, IT WILL DO US LITTLE GOOD TO PURSUE MORE WRITTEN AGREEMENTS WITH THE SOVIETS AFTER CHERNOBYL UNLESS WE THINK THEY INTEND TO FULFILL THEM. THEIR RECORD THUS FAR IS ABYSMAL AND I FOR ONE AM SCEPTICAL THAT EVEN THE BEST, MOST TECHNICAL AND MOST PERFECT NUCLEAR SAFETY AGREEMENT THE WEST MIGHT EXTRACT FROM GORBACHEV NOW WOULD BE WORTH MUCH, GIVEN THE SOVIET DISREGARD FOR AND DISTAIN FOR THE PROMISES IT MADE ON THE ENVIRONMENT IN THE HELSINKI ACCORDS.

I ASK UNANIMOUS CONSENT THAT THE RELEVANT PAGES OF THE HELSINKI ACCORDS BE INSERTED IN THE HEARING RECORD AS PART OF MY STATEMENT.

The Department of State

Bulletin Reprint

Bureau of Public Affairs
Office of Media Services

# CONFERENCE ON SECURITY AND COOPERATION IN EUROPE: FINAL ACT, HELSINKI, 1975

The Conference on Security and Co-operation in Europe, which opened at Helsinki on 3 July 1973 and continued at Geneva from 18 September 1973 to 21 July 1975, was concluded at Helsinki on 1 August 1975 by the High Representatives of Austria, Belgium, Bulgaria, Canada, Cyprus, Czechoslovakia, Denmark, Finland, France, the German Democratic Republic, the Federal Republic of Germany, Greece, the Holy See, Hungary, Iceland, Ireland, Italy, Liechtenstein, Luxembourg, Malta, Monaco, the Netherlands, Norway, Poland, Portugal, Romania, San Marino, Spain, Sweden, Switzerland, Turkey, the Union of Soviet Socialist Republics, the United Kingdom, the United States of America and Yugoslavia.

During the opening and closing stages of the Conference the participants were addressed by the Secretary-General of the United Nations as their guest of honour. The Director-General of UNESCO and the Executive Secretary of the United Nations Economic Commission for Europe addressed the Conference during its second stage.

During the meetings of the second stage of the Conference, contributions were received, and statements heard, from the following non-participating Mediterranean States on various agenda items: the Democratic and Popular Republic of Algeria, the Arab Republic of Egypt, Israel, the Kingdom of Morocco, the Syrian Arab Republic, Tunisia.

Motivated by the political will, in the interest of peoples, to improve and intensify their relations and to contribute in Europe to peace, security, justice and co-operation as well as to rapprochement among themselves and with the other States of the world,

Determined, in consequence, to give full effect to the results of the Conference and to assure, among their States and throughout Europe, the benefits deriving from those results and thus to broaden, deepen and make continuing and lasting the process of détente,

The High Representatives of the participating States have solemnly adopted the following:

## QUESTIONS RELATING TO SECURITY IN EUROPE

The States participating in the Conference on Security and Co-operation in Europe,

*Reaffirming* their objective of promoting better relations among themselves and ensuring conditions in which their people can live in true and lasting peace free from any threat to or attempt against their security;

*Convinced* of the need to exert efforts to make détente both a continuing and an increasingly viable and comprehensive process, universal in scope, and that the implementation of the results of the Conference on Security and Co-operation in Europe will be a major contribution to this process;

*Considering* that solidarity among peoples, as well as the common purpose of the participating States in achieving the aims as set forth by the Conference on Security and Co-operation in Europe, should lead to the development of better and closer relations among them in all fields and thus to overcoming the confrontation stemming from the character of their past relations, and to better mutual understanding;

*Mindful* of their common history and recognizing that the existence of elements common to their traditions and values can assist them in developing their relations, and desiring to search, fully taking into account the individuality and diversity of their positions and views, for possibilities of joining their efforts with a view to overcoming distrust and increasing confidence, solving the problems that separate them and co-operating in the interest of mankind;

*Recognizing* the indivisibility of security in Europe as well as their common interest in the development of co-operation throughout Europe and among themselves and expressing their intention to pursue efforts accordingly;

*Recognizing* the close link between peace and security in Europe and in the world as a whole and conscious of the need for each of them to make its contribution to the strengthening of world peace and security and to the promotion of fundamental rights, economic and social progress and well-being for all peoples;

*Have adopted the following:*

### 1.

### (a) Declaration on Principles Guiding Relations between Participating States

The participating States,

*Reaffirming* their commitment to peace, security tific developments, including the conclusion of mutually beneficial co-operation arrangements between firms and enterprises in fields agreed upon between them and for carrying out, where appropriate, joint research and development programmes and projects;

consider it desirable that periodic exchanges of views and information take place on scientific policy, in particular on general problems of orientation and administration of research and the question of a better use of large-scale scientific and experimental equipment on a co-operative basis;

recommend that, in developing co-operation in the field of science and technology, full use be made of existing practices of bilateral and multilateral co-operation, including that of a regional or sub-regional character, together with the forms and methods of co-operation described in this document;

recommend further that more effective utilization be made of the possibilities and capabilities of existing international organizations, intergovernmental and non-governmental, concerned with science and technology, for improving exchanges of information and experience, as well as for developing other forms of co-operation in fields of common interest, for example:

—in the United Nations Economic Commission for Europe, study of possibilities for expanding multilateral co-operation, taking into account models for projects and research used in various international organizations; and for sponsoring conferences, symposia, and study and working groups such as those which would bring together younger scientists and technologists with eminent specialists in their field;

—through their participation in particular international scientific and technological co-operation programmes, including those of UNESCO and other international organizations, pursuit of continuing progress towards the objectives of such programmes, notably those of UNISIST [World Science Information System] with particular respect to information policy guidance, technical advice, information contributions and data processing.

## 5. Environment

**The participating States,**

***Affirming*** **that the protection and improvement of the environment, as well as the protection of nature and the rational utilization of its resources in the interests of present and future generations, is one of the tasks of major importance to the well-being of peoples and the economic development of all countries and that many environmental problems, particularly in Europe, can be solved effectively only through close international co-operation,**

***Acknowledging*** **that each of the participating States, in accordance with the principles of international law, ought to ensure, in a spirit of co-operation, that activities carried out on its territory do not cause degradation of the environment in another State or in areas lying beyond the limits of national jurisdiction,**

***Considering*** **that the success of any environmental policy presupposes that all population groups and social forces, aware of their responsibilities, help to protect and improve the environment, which necessitates continued and thorough educative action, particularly with regard to youth,**

*Affirming* that experience has shown that economic development and technological progress must be compatible with the protection of the environment and the preservation of historical and cultural values; that damage to the environment is best avoided by preventive measures; and that the ecological balance must be preserved in the exploitation and management of natural resources,

### *Aims of co-operation*

Agree to the following aims of co-operation, in particular:

—to study, with a view to their solution, those environmental problems which, by their nature, are of a multilateral, bilateral, regional or sub-regional dimension; as well as to encourage the development of an interdisciplinary approach to environmental problems;

—to increase the effectiveness of national and international measures for the protection of the environment, by the comparison and, if appropriate, the harmonization of methods of gathering and analyzing facts, by improving the knowledge of pollution phenomena and rational utilization of natural resources, by the exchange of information, by the harmonization of definitions and the adoption, as far as possible, of a common terminology in the field of the environment;

—to take the necessary measures to bring environmental policies closer together and, where appropriate and possible, to harmonize them;

—to encourage, where possible and appropriate, national and international efforts by their interested organizations, enterprises and firms in the development, production and improvement of equipment designed for monitoring, protecting and enhancing the environment.

### *Fields of co-operation*

To attain these aims, the participating States will make use of every suitable opportunity to co-operate in the field of environment and, in particular, within the areas described below as examples:

#### *Control of air pollution*

Desulphurization of fossil fuels and exhaust gases; pollution control of heavy metals, particles, aerosols, nitrogen oxides, in particular those emitted by transport, power stations, and other industrial plants; systems and methods of observation and control of air pollution and its effects, including long-range transport of air pollutants;

#### *Water pollution control and fresh water utilization*

Prevention and control of water pollution, in particular of transboundary rivers and international lakes; techniques for the improvement of the quality of water and further development of ways and means for industrial and municipal sewage effluent purification; methods of assessment of fresh water resources and the improvement of their utilization, in particular by developing methods of production which are less polluting and lead to less consumption of fresh water;

#### *Protection of the marine environment*

Protection of the marine environment of participating States, and especially the Mediterranean Sea, from pollutants emanating from land-based sources and those from ships and other vessels, notably the harmful substances listed in Annexes I and II to the London Convention on the Prevention of Marine Pollution by the Dumping of Wastes and Other Matters; problems of maintaining marine ecological balances and food chains, in particular such problems as may arise from the exploration and exploitation of biological and mineral resources of the seas and the sea-bed;

*Land utilization and soils*

Problems associated with more effective use of lands, including land amelioration, reclamation and recultivation; control of soil pollution, water and air erosion, as well as other forms of soil degradation; maintaining and increasing the productivity of soils with due regard for the possible negative effects of the application of chemical fertilizers and pesticides;

*Nature conservation and nature reserves*

Protection of nature and nature reserves; conservation and maintenance of existing genetic resources, especially rare animal and plant species; conservation of natural ecological systems; establishment of nature reserves and other protected landscapes and areas, including their use for research, tourism, recreation and other purposes;

*Improvement of environmental conditions in areas of human settlement*

Environmental conditions associated with transport, housing, working areas, urban development and planning, water supply and sewage disposal systems; assessment of harmful effects of noise, and noise control methods; collection, treatment and utilization of wastes, including the recovery and recycling of materials; research on substitutes for non-biodegradable substances;

*Fundamental research, monitoring, forecasting and assessment of environmental changes*

Study of changes in climate, landscapes and ecological balances under the impact of both natural factors and human activities; forecasting of possible genetic changes in flora and fauna as a result of environmental pollution; harmonization of statistical data, development of scientific concepts and systems of monitoring networks, standardized methods of observation, measurement and assessment of changes in the biosphere; assessment of the effects of environmental pollution levels and degradation of the environment upon human health; study and development of criteria and standards for various environmental pollutants and regulation regarding production and use of various products;

*Legal and administrative measures*

Legal and administrative measures for the protection of the environment including procedures for establishing environmental impact assessments.

## *Forms and methods of co-operation*

The participating States declare that problems relating to the protection and improvement of the environment will be solved on both a bilateral and a multilateral, including regional and sub-regional, basis, making full use of existing patterns and forms of co-operation. They will develop co-operation in the field of the environment in particular by taking into consideration the Stockholm Declaration on the Human Environment, relevant resolutions of the United Nations General Assembly and the United Nations Economic Commission for Europe Prague symposium on environmental problems.

The participating States are resolved that co-operation in the field of the environment will be implemented in particular through:

—exchanges of scientific and technical information, documentation and research results, including information on the means of determining the possible effects on the environment of technical and economic activities;

—organization of conferences, symposia and meetings of experts;

—exchanges of scientists, specialists and trainees;

—joint preparation and implementation of programmes and projects for the study and solution of various problems of environmental protection;

—harmonization, where appropriate and necessary, of environmental protection standards and norms, in particular with the object of avoiding possible difficulties in trade which may arise from efforts to resolve ecological problems of production processes and which relate to the achievement of certain environmental qualities in manufactured products;

—consultations on various aspects of environmental protection, as agreed upon among countries concerned, especially in connexion with problems which could have international consequences.

The participating States will further develop such co-operation by:

—promoting the progressive development, codification and implementation of international law as one means of preserving and enhancing the human environment, including principles and practices, as accepted by them, relating to pollution and other environmental damage caused by activities within the jurisdiction or control of their States affecting other countries and regions;

—supporting and promoting the implementation of relevant international Conventions to which they are parties, in particular those designed to prevent and combat marine and fresh water pollution, recommending States to ratify Conventions which have already been signed, as well as considering possibilities of accepting other appropriate Conventions to which they are not parties at present;

—advocating the inclusion, where appropriate and possible, of the various areas of co-operation into the programmes of work of the United Nations Economic Commission for Europe, supporting such co-operation within the framework of the Commission and of the United Nations Environment Programme, and taking into account the work of other competent international organizations of which they are members;

—making wider use, in all types of co-operation, of information already available from national and international sources, including internationally agreed criteria, and utilizing the possibilities and capabilities of various competent international organizations.

The participating States agree on the following recommendations on specific measures:

—to develop through international co-operation an extensive programme for the monitoring and evaluation of the long-range transport of air pollutants, starting with sulphur dioxide and with possible extension to other pollutants, and to this end to take into account basic elements of a co-operation programme which were identified by the experts who met in Oslo in December 1974 at the invitation of the Norwegian Institute of Air Research;

—to advocate that within the framework of the United Nations Economic Commission for Europe a study be carried out of procedures and relevant experience relating to the activities of Governments in developing the capabilities of their countries to predict adequately environmental consequences of economic activities and technological development.

## 6. Co-operation in other areas

### *Development of transport*

**The participating States,**

*Considering* that the improvement of the conditions of transport constitutes one of the factors essential to the development of co-operation among them,

*Considering* that it is necessary to encourage the development of transport and the solution of existing problems by employing appropriate national and international means,

*Taking into account* the work being carried out on these subjects by existing international organizations, especially by the Inland Transport Committee of the United Nations Economic Commission for Europe,

note that the speed of technical progress in the various fields of transport makes desirable a development of co-operation and an increase in exchanges of information among them;

declare themselves in favour of a simplification and a harmonization of administrative formalities in the field of international transport, in particular at frontiers;

consider it desirable to promote, while allowing for their particular national circumstances in this sector, the harmonization of administrative and technical provisions concerning safety in road, rail, river, air and sea transport;

express their intention to encourage the development of international inland transport of passengers and goods as well as the possibilities of adequate participation in such transport on the basis of reciprocal advantage;

declare themselves in favour, with due respect for their rights and international commitments, of the elimination of disparities arising from the legal provisions applied to traffic on inland waterways which are subject to international conventions and, in particular, of the disparity in the application of those provisions; and to this end invite the member States of the Central Commission for the Navigation of the Rhine, of the Danube Commission and of other bodies to develop the work and studies now being carried out, in particular within the United Nations Economic Commission for Europe;

express their willingness, with a view to improving international rail transport and with due respect for their rights and international commitments, to work towards the elimination of difficulties arising from disparities in existing international legal provisions governing the reciprocal railway transport of passengers and goods between their territories;

express the desire for intensification of the work being carried out by existing international organizations in the field of transport, especially that of the Inland Transport Committee of the United Nations Economic Commission for Europe, and express their intention to contribute thereto by their efforts;

consider that examination by the participating States of the possibility of their accession to the different conventions or to membership of international organizations specializing in transport matters, as well as their efforts to implement conventions when ratified, could contribute to the strengthening of their co-operation in this field.

### *Promotion of tourism*

**The participating States,**

*Aware of* the contribution made by international tourism to the development of mutual understanding among peoples, to increased knowledge of other countries' achievements in various fields, as well as to economic, social and cultural progress,

*Recognizing* the interrelationship between the development of tourism and measures taken in other areas of economic activity,

express their intention to encourage increased tourism on both an individual and group basis in particular by:

—encouraging the improvement of the tourist infrastructure and co-operation in this field;

—encouraging the carrying out of joint tourist projects including technical co-operation, particularly where this is suggested by territorial proximity and the convergence of tourist interests;

—encouraging the exchange of information, including relevant laws and regulations, studies, data and documentation relating to tourism, and by improving statistics with a view to facilitating their comparability;

—dealing in a positive spirit with questions connected with the allocation of financial means for tourist travel abroad, having regard to their economic possibilities, as well as with those connected with the formalities required for such travel, taking into account other provisions on tourism adopted by the Conference;

—facilitating the activities of foreign travel agencies and passenger transport companies in the promotion of international tourism;

—encouraging tourism outside the high season;

—examining the possibilities of exchanging specialists and students in the field of tourism, with a view to improving their qualifications;

—promoting conferences and symposia on the planning and development of tourism;

consider it desirable to carry out in the appropriate international framework, and with the co-operation of the relevant national bodies, detailed studies on tourism, in particular:

—a comparative study on the status and activities of travel agencies as well as on ways and means of achieving better co-operation among them;

Senator WALLOP. I would like to make the first point that is in it because I think it is important. There is a myth circulating both here in this country and abroad that the Soviet Union had no written obligation to inform the world immediately of the Chernobyl nuclear reactor accident.

This committee heard that myth repeated by a State Department witness who appeared before us in a briefing following the accident, by foreign experts and by the news media. We have heard this factoid repeated by many responsible officials of the International Atomic Energy Agency in the course of their interviews and briefings to inform the public and the world on the details of the Chernobyl disaster.

The fact of the matter is, Mr. Chairman, that the Soviet Union did and does have a written international obligation to inform the world immediately of the Chernobyl accident. That obligation is enshrined in the final act of the Helsinki Conference on Security and Cooperation in Europe, signed by 35 nations, including the Soviet Union in Helsinki, Finland, 1975. It is contained specifically in there.

I just wanted the committee to know that, for whatever reasons, we continue to make apologies for behavior that is intolerable on the world's scene. I think much of the health problem and much of the dimension of the accident is related specifically to the Soviet Union's inability to come to grips with failure, even with their own people.

Their failure to inform them is even more intolerable than their failure to inform the public. But I think the dimensions of the accident is clearly related to the unwillingness to react immediately to the Soviet people.

In light of that, and I know, Mr. Myers, you cannot answer this question, but I wish you would take it back and have it answered for us; we have been contacted in our office by a number of Americans of Ukrainian descent.

I received a letter from the White House, basically passing the buck to Mr. Thomas at EPA on the issue of how these Americans with family members in the Ukraine would be able to communicate with them as a result of the accident. My question to be answered for the record is, What will EPA, as coordinator of the Chernobyl task force do to promote such family communications?

Mr. MEYERS. I think we did get that request, and as the task force has essentially broken up, that would be a normal responsibility of the State Department, and the response will essentially say the State Department will take care of that for you.

The CHAIRMAN. The buck goes back.

Senator WALLOP. The buck goes round and round. It never stops. Well, Mr. Chairman, I wish the committee would write the State Department and see if it stops somewhere along the line. These people are rightfully concerned; family members whom they may never see again.

The CHAIRMAN. That will be submitted to the State Department for response for the record for this hearing.

Senator WALLOP. I thank the chairman. Mr. Denton, Mr. Wade, the Soviets are building nuclear reactors in Cuba. There is some speculation in the press that it was the same type reactor that was at Chernobyl, other speculation that it is not.

The question is, Do we know what types of reactors are being built and are we faced with the same casual attitude toward safety that apparently triggered the Chernobyl accident?

Dr. BUNCH. It is my understanding that the reactors in Cuba are what are called VVER-400; namely, 400 megawatt class, pressurized water reactors. It is also my understanding that the particular designs are the Soviet export models, with containments, somewhat analogous to U.S. PWR's of that size.

I am finally given to understand that the particular concept chosen is one similar to that already being operated in Hungary. The Soviets claim that it has substantial safety features not found in the RBMK, the Chernobyl type of design. Whether or not its construction quality and the details of the safety systems are what we would expect in this country I think is doubtful, but I don't have the details of the Cuban design at this point.

Senator WALLOP. Have we ever had any access to the Soviet reactors and their buildings and design so we have some confidence in how——

Dr. BUNCH. There have been a number of United States citizens who have been granted tours of Soviet reactors in the past. There have been extensive discussions, for example, with the Fins, who have a Soviet style machine. The Fins, and the Germans have had full access to many of the design documents of some of these systems and have been asked to evaluate them.

One of the benefits of a multinational, international nuclear society is that we do in fact, have broad access to information about these systems.

Senator WALLOP. Do we have broad access yet to the information of all the details of the Chernobyl accident?

Dr. BUNCH. As Mr. Denton and I both were trying to convey, we have exhaustively examined the Soviet literature that has been published. There is much that we don't have.

Senator WALLOP. That is not precisely my question.

Dr. BUNCH. I was giving you a long "no," sir.

Senator WALLOP. That is what I was afraid you were giving me.

Mr. DENTON. Senator, we have attempted to carry on a dialog on safety with all countries, but when they invaded Afghanistan, as a matter of national policy, we terminated that discussion with the Soviets. We have not had a safety discussion with them since that time.

Senator WALLOP. Has anyone?

Mr. DENTON. I can only speak for the NRC. We were in the process of trying to reestablish that communication link when Chernobyl occurred.

Senator WALLOP. Mr. Meyers, can you add anything to that? Presumably if they are not talking to us—not presumably at all, but maybe me if they are not talking to us they are talking to somebody else and presumably we could have access to that information.

Mr. MEYERS. Well, they clearly have spoken to the IAEA management who, as you know, have been there. They apparently have made certain agreements with them to release information. We have not seen any of it yet. I understand there is an international conference to be taking place in several months that everybody is looking forward to that is being advertised as getting more information on Chernobyl. But, as of today, we have very sparse information on what happened at the site itself in terms of actual measurements.

Ms. **WALKER**. If I might, Senator Wallop. It is my understanding that that briefing is tentatively scheduled to take place near the end of August, I believe 23 or 24, and at that time there will be a briefing by the Soviets on the accident, and information will be presented at that time and I believe this is being done under the IAEA and will occur in Vienna.

Senator **WALLOP**. Do we have any reason to feel confident that we will have the basic information necessary to make judgments about it, or will we have a tailored set of facts?

Ms. **WALKER**. It is expected that all of our questions will not be answered, but that we will have more information than we have now and perhaps enough information so that we will understand the implications for our own industry.

Mr. **DENTON**. Senator, I think they do intend to provide a lot of information. I spoke to the head of the delegation; mentioned the type of investigation we did after TMI. I don't expect that sort of report to come out, but they do indicate that they intend to spend several days telling us what happened and that they will be taking questions from experts in the various technical areas. So I am very hopeful this will be the first opportunity to get to——

Senator **WALLOP**. Four months is time to make up a good story and rehearse it well. Thank you, Mr. Chairman.

The **CHAIRMAN**. Thank you, Senator Wallop.

Senator Bumpers.

## STATEMENT OF HON. DALE BUMPERS, A U.S. SENATOR FROM THE STATE OF ARKANSAS

Senator **BUMPERS**. Thank you. Mr. Denton, and to all the members of the panel, let me say, first of all, in light of the ominous warnings of the greenhouse theory and what is going to happen if we continue to burn coal, this hearing is very important because we may find ourselves having to rely almost exclusively on nuclear power in the short term. This may be necessary because it is a cleaner fuel and does not cause the air pollution problems that coal and oil do.

So I think it is incumbent upon us, No. 1, not to be defensive about nuclear power and the safety of it, or make comparisons with the Soviet Union's safety record, but to look at this very realistically and recognize that we must on a continuing basis continue to consider the safety of our reactors, and how they might be improved.

Now, what was the Soviet safety record prior to Chernobyl?

Mr. **DENTON**. I don't think I can shed much light on that.

Senator **BUMPERS**. Anybody on the panel who can?

Mr. **DENTON**. We exchange, with most of the countries of the free world, information on unusual operating events, abnormal occurrences, and I could do a much better job with most countries, other than the Soviet Union. They haven't provided much data to the IAEA up to now and therefore we have very little hard facts. Perhaps someone else could——

Senator **Bumpers**. Well, so far as we know then, up until Chernobyl, they had a better record than we did? After all, we had TMI in 1979.

Ms. **Walker**. Senator Bumpers, I would like to ask Mr. Ofte, Deputy Assistant Secretary, Defense Programs, who may have a comment.

Senator **Bumpers**. Fine.

Mr. **Ofte**. I think that there is a pattern when we look back over—perhaps not the reactor program because we don't have much insight into it, but when we look back at Kyshtym, where the Russians engaged, as near as we can analyze by the data we have gotten, in some very poor practices in handling their radioactive wastes, they despoiled a very large region of their country with those practices in the 1950's.

Likewise, I think there is a little insight that we can get on their practices when we recall the reactor satellite that crashed into Canada and what their response was to that. Then, I guess finally, we have a limited Test Ban Treaty that we have entered into with the Russians that requires release of any radionuclides from underground nulear testing, do not go beyond the borders of the country.

We have evidence that says they repeatedly violated that treaty and don't respond by changing their practices.

Senator **Bumpers**. My question really goes directly to the safety of their civilian reactors.

Mr. **Ofte**. Yes, sir. These are analogies I can't talk to Soviet reactor safety because I am not knowledgeable in that area, sir.

Senator **Bumpers**. Our job here is not to determine the comparative safety of ours with theirs; our job here is to make certain that ours are as safe as we can possibly make them and reassure the people of this country. And that is the reason that Senator Johnston and some of us have requested the chairman call this hearing today, and to make sure that there is not some kind of accommodation of the industry here in the operation of these plants.

For example, I am looking at an article here from the Washington Post, May 6 of this year. It says,

> Last year, even as the industry compiled its worse safety record since TMI, experiencing significant mishaps with 10 percent of the U.S. plants, experiencing significant mishaps, or management lapses, Commission rulings set up procedural hurdles for imposing safety modifications on plants and gave utilities the right to regulate themselves in important areas of employee training and fitness for work standards.

What do you have to say to that, Mr. Denton?

Mr. **Denton**. Let me give a long answer. I think we are a lot tougher now than we were pre-TMI. I think pre-TMI, the Agency felt that severe accidents were just precluded by design and therefore would not happen.

Since that time, we have started giving utilities scorecards or grades and there are some well operating utilities in the United States, plants like Kewaunee and Point Beach just consistently operate without any upsets. They are reliable plants, low occupational exposures, and I think our goal today is to bring all plants up to that level of performance.

We are also trying to be tougher on the poor performers and you have seen a lot of activity with regard to plants like Rancho Seco, Diablo Canyon, and TVA, where the performance is not up to par. I think it turns out that with 50 or 60 utilities to regulate, the biggest factor today in terms of safety, is the commitment and dedication of utility management. It has been a big effort to upgrade it.

Problems do continue to occur, but I think our threshold to problems is a lot lower than it was at TMI, and we are trying to act on glimmers, precursors that we might have just not even dealt with before TMI. In some areas, like accreditation, I think it is true that the industry proposed a process to accredit operators and after much debate, the Commissioners, themselves voted that they would give the utilities a chance to demonstrate that that program could work.

I have been asked, as a member of the staff, to monitor that program and give the Commission a report back, as I do periodically.

Senator **Bumpers**. Mr. Denton, I don't understand your answer. What I am asking is, in light of TMI, 1979, and the task force that studied that and the recommendations that were made, here is a statement that I would like you to either admit or deny.

Six years after TMI, this industry experienced its worse accident record in history, with 10 percent of the U.S. plants experiencing significant mishaps.

How can you account for that 6 years after TMI—the worse record—this article calls it.

Mr. **Denton**. I guess I would deny that that is the worse year. We have had problems every year somewhere in the United States. We had the Salem issue several years ago. Each year we have several events that occur that demand a lot of our attention.

I looked back several months ago as to whether I could really see a trend and I think overall, the trend in general, is improving, although I must admit there are some occasional bad performers that got into that list. I don't think it is the worse year ever.

I think, by and large, if you count all 102 plants which are in operation today, the total trend is upward, although there are still plants which deserve a lot more regulatory attention. That is what we are trying to get them.

Senator **Domenici**. Would the Senator yield for a clarification question?

Senator **Bumpers**. Yes.

Senator **Domenici**. I don't understand what he means, and maybe it does have something to do with the answer. You said, "We have changed the threshold level." I think I know what that means. Could you tell us? I am not sure that everybody understood what that means. I am not sure at this point. Could you tell us what that means?

Mr. **Denton**. I think that means we have gotten tougher, or pay a lot more attention to all occurrences than before TMI. We put resident inspectors, you recall, at all sites. Many sites now have three or four NRC employees there.

We go to around-the-clock inspections, as we did up in Boston, when we suspect a problem. The scrutiny that we give plants has increased considerably. When there is a breakdown, we try to use that as a glimmer that there is a problem and jump on it. We find them, we take enforcement action.

So I think these issues get a lot more attention now than they did pre-TMI. It does not mean that the safety record was worse; I would like to think it means that we are getting on problems before they turn into real problems.

Senator **Domenici**. I thank the Senator.

Senator **Bumpers**. Thank you, Senator. In the same article, Mr. Denton, it says that two declarations by the five-member panel, last year, sum up what critics consider to be a laissez faire regulatory philosophy. Four months after the Commission projected a 45 percent probability of a severe reactor core meltdown within the next 20 years—45, that is almost a 50 percent probability—the Commission concluded that today's plants pose no undue level of risk to the public.

That seems to me a contradiction, is it not?

Mr. **Denton**. That I think is the issue which has bedeviled the Commission with regard to how safe is safe enough? We have, as the staff of the Commission, estimates on what the probability is of TMI-type accidents occurring again in this country, or worse accidents occurring in this country.

We can give them probability and consequences. They make the judgments on what is safe enough in terms of the level of safety. I think safety in some sense can be judged by the individual who asks "safe compared to what?" They made the statement and I would prefer that they give you their basis for having said that.

Senator **Bumpers**. Mr. Denton, I am going to introduce a bill today calling for the President and others, and I won't go into detail on the legislation, to appoint a 12-person commission to get deeply involved in the study of nuclear safety issues. How would you feel about that?

The reason I did this is because I remember when the shuttle exploded and people were calling and saying, if the appoint a blue ribbon panel to study this, I would certainly like to be on it. I was saying, listen, nobody has the integrity that NASA has. I am sure there will be an in-house study here that will be great, and clarify this whole thing. I know they have done everything they can possibly do.

It never occurred to me what was going to come out of the blue ribbon panel's investigation of the shuttle accident. I am not suggesting the NRC is in the same boat, but I think just for my own feelings about it, and the feelings of the American people, who have a right to be assured that we are doing all we can—and I am not just suggesting a one-shot deal. Independent safety reviews ought to be done periodically.

Do you have any objection to that?

Mr. **Denton**. Senator, my own personal opinion, having worked in this agency for 20 years, is I would stay with the single administrator approach that is pending before Congress. I think by having five commissioners we have not clearly selected a course of action all of the time. I would prefer a single administrator that you could hold accountable, that would give the staff marching orders and it would be clear that we are carrying out the mandate of Congress.

Senator BUMPERS. I must confess, Mr. Denton, I don't feel comfortable with that at all. I know that Commissioner Asselstine is not everybody's favorite Commissioner over there, but I think you need a maverick on every commission; somebody just to stir up the water. He may even be irresponsible at times, but he will at least get your attention and cause you to focus on something.

He says, "The memory of Three Mile Island has faded and complacency about safety has set in." Now obviously, you would disagree with that.

Mr. DENTON. My experience has been—and not dealing in personalities at all—but every person——

Senator BUMPERS. It is unfair of me to ask you.

Mr. DENTON. But I would like to qualify it. The Commission form of government seems to polarize individuals and we spend—just speaking as a staff member, we are very ineffective because of the lack of a single leader on the Commission. Strictly speaking in terms of the effectiveness of the Commission. I think the bills before Congress which strengthen the leadership are ones that would produce a more effective Commission regardless of what your attitude toward whether safety should be increased or not.

Senator BUMPERS. Mr. Denton. I don't know whether you are the proper person to ask this last question or not, my time is up, and I will be back and we will cover more of this. But I did want to talk about evacuations.

It is a policy in this country by the NRC, to evacuate, plant evacuations within 10 miles. How many people live within 10 miles of Indian Point, and No. 2, in light of Chernobyl, do you think that policy ought to be reevaluated since they had to evacuate almost 20 miles out?

Mr. DENTON. In developing the 10-mile policy, we looked at a spectrum of accidents. We didn't just assume that containment would work as it did at TMI. However, we do intend to take another look at the 10 mile policy. Prior to Chernobyl, there was a move toward reducing the emergency planning zone because all the research that has been done shows that if the containment works properly, most of the activity stays inside.

I had gotten a petition from Calvert Cliffs, which is not too far from Washington, down on the bay, to reduce their emergency planning zone from 10 miles to 2 miles. I denied that petition as premature, until we had completed all the scientific research that needed to go on.

I do intend to look at that matter again, in light of Chernobyl. How many people live within 10 miles of Indian Point?

Senator BUMPERS. How many people lived within 10 miles of Chernobyl?

Mr. DENTON. I think roughly 100,000 people were evacuated.

Senator BUMPERS. That was about a 16 or 17 mile area, was it not?

Mr. DENTON. Yes, sir. And the evacuation radius kept expanding as time went by.

Senator BUMPERS. Well, you did not answer my question: How many people live within 10 miles of Indian Point?

Mr. DENTON. I don't have that answer, Senator, but I would be happy to supply it. Perhaps someone here from FEMA might have a feel for it.

Senator BUMPERS. Well, Senator Metzenbaum came well prepared. Give them the figures.

Senator METZENBAUM. 218,398, and I think there were a couple of births since that figure.

Senator BUMPERS. It may be like my hometown; we never could grow because every time a baby was born, somebody had to leave town.

The CHAIRMAN. Senator Murkowski.

## STATEMENT OF HON. FRANK H. MURKOWSKI, A U.S. SENATOR FROM THE STATE OF ALASKA

Senator MURKOWSKI. I have a statement which I would ask unanimous consent be entered in the record.

The CHAIRMAN. So ordered.

### STATEMENT OF HON. FRANK H. MURKOWSKI, A U.S. SENATOR FROM THE STATE OF ALASKA

Good morning Mr. Chairman, Ladies and Gentlemen. Mr. Chairman, I commend you for holding this very important hearing. There are many lessons we can learn from the Chernobyl accident and this hearing is the necessary first step to that process.

I recognize that the primary purpose of this hearing is to explore the impacts of the Chernobyl accident on our domestic nuclear power industry. I trust that the witnesses will cover that matter thoroughly in their presentations. However, I would like to focus for a moment on another aspect of the accident. An aspect which is more people related than the central theme of this hearing.

Reports continue to reach us that the Soviet nuclear disaster a Chernobyl may be more extensive than was previously indicated.

Chernobyl is located in the heart of the Soviet Union's breadbasket—the "black earth" region of the Ukraine which has traditionally provided the vast majority of Russia's food. It now appears that a significant part of that area has been contaminated by radioactive fallout from the accident. Dairy and meat herds have also been affected. At this time of year, many Russian fields lie plowed and open, making it easier for contamination to sink deeper into the soil.

If these reports are true, the Russians could be facing an enormous human tragedy. They already have difficulty raising enough food to feed their population. Fallout from this accident could make that problem worse, perhaps much worse for years to come.

I have been a frequent critic of the Soviet Union. I have condemned its repression of freedom at home, its actions in Afghanistan and Poland, its continued military buildup. But there are times when we have to set our differences aside and respond as human beings to a human tragedy.

This accident is not a political issue, it is a humanitarian one. I strongly support the President's offer to the Soviets of all possible assistance—not only to cope with the immediate problem of the reactor meltdown, but to deal with the long-term problems, including health and food supply.

This is not just altruism: it involves our own security and safety. The cloud of radioactive dust from Chernobyl is being carried around the world. This accident reminds us that, in the nuclear age, the fortunes of our two countries—indeed, of the entire world—are ultimately bound together.

This could prove an historic opportunity for us to work together with our Soviet adversaries on a problem which threatens us both. What is needed is an international effort to pool our knowledge about how we can deal with this unprecedented, international problem.

The world is ready to help the Russian people in this time of national disaster. But the secrecy with which the Soviets surround such tragedies makes it difficult to do so. Whether it is pride, a misplaced sensitivity about security, a reluctance to admit mistakes—whatever it is—this approach is unnecessary and tragic. The secrecy makes it extremely difficult for nations of the world to know the seriousness of the tragedy and the degree of help needed.

Mikhail Gorbachev has spoken of a new openness and frankness he would like to see in Soviet society. Now is the time for him to put that into practice. I call on him not to retreat into defensive attitudes concerning this disaster, but to accept our offer of aid in the sincere and genuine spirit in which it is made. The Soviet people need to know that America takes no joy in this tragedy. Instead, we are ready to help—with technical and medical assistance, food, or whatever is needed—as generously as possible.

Senator MURKOWSKI. My first question is relative to the uniqueness of the opportunity to attempt to work with the Soviets for the benefit of both our own research and potential contribution toward ensuring that such an accident does not reoccur.

I am curious, Mr. Chairman, to have a forecast, if you will, of the likelihood of the Soviets being agreeable to working in concert to in detail evaluate the shortcomings of the Soviet safeguard system, so that we can both learn and share this knowledge with those other countries that use nuclear power generation or are contemplating it.

In your opinion, is there a likelihood that the atmosphere of mutual concern and sharing might realistically come out of this for the advancement of nuclear technology? Or, do you have reservations?

Dr. BUNCH. Senator, I think it is a little too soon to tell. Shortly after the accident, as you may recall, Mr. Gorbachev came on the air and he issued to the United Nations a written statement about his intent to cooperate on improving the safety practices in the international community which I presume means he is willing to do more in his own country.

I think we will have a better understanding when the Soviets sit down with us and other member nations of the International Atomic Energy Agency in July, to talk about possible conventions for mutual emergency assistance, and reporting. I think that before Chernobyl, there was work going on with the IAEA to secure agreement with the Soviets, to allow inspection of these teams on how effective were the operational practices.

If that is extended, I think the answer will be yes, but it is too soon to tell to see how much actual improvement we are going to see in the willingness.

Senator MURKOWSKI. You are just waiting out there and saying that it is probably too soon to tell.

Mr. DENTON. I am saying that the Soviets have said they want to try to do better. What that means, I think we have to wait and see.

Senator MURKOWSKI. I am concerned, if you will, over the ability to analyze the traditional Soviet patterns, where they have been criticized by basically the entire free world for the manner in which they have handled this. Yet, I am heightened by their willingness to take some of our specialists in bone marrow transplants and so forth, and bring over for the rehabilitation of those who can be helped.

I guess I am a little disappointed that we are not a little further along on a clear signal as to what the Soviets may determine. I am also concerned with their traditional track record of cloistering in when they do have a difficulty.

My next question is what is the significance of the degree of inaccuracy, misinformation, that came out of our own media in the first information flow that came out of the Soviet Union? We obviously were unable, even within reasonable limits, to pinpoint the significance of those that were allegedly killed or those that were exposed to such an extent that there would be mass annihilation, up to a few hundred thousand, or maybe more, much greater anticipated devastation than actually occurred.

Was this just a situation where the press was over-exuberant, or was there some other reason?

Mr. DENTON. Speaking as a member of the task force, we didn't rely on ham radios out of Kiev, and those sort of sources that I think some media relied on in the first few days. We tried to rely only on facts that we could verify or calculate. I think the absence of information from the Soviet Union during this first few days led to that sort of speculation.

Senator MURKOWSKI. The Soviets were denying that it was that bad and we kept saying it was that bad, or inferred that it was. I can recall headlines in New York papers that would really scare the devil out of you.

Mr. DENTON. But I can remember the same sort of headlines during TMI, and it seemed to vary with distance. The further way from the accident, the more erroneous the report. But I think as members of the task force, we tried to report information that we really knew to be essentially correct.

Senator MURKOWSKI. You do not feel at all responsible for the misinformation that was carried by the media?

Mr. DENTON. I think we felt responsible to try to tell the media what we knew. I don't feel responsible, that is correct, for what the media prints.

Senator MURKOWSKI. My last question, Mr. Chairman is, there was reference in the statement of Mr. Delbert Bunch, toward increased simplicity. I am wondering, Mr. Bunch, if you could elaborate on why we can't more or less have a customized nuclear powerplant, one that has met all the requirements—the licensing, not for the first time, but for the 10, 11 and 12 times, so that we are not almost customizing each time we do a new reactor.

I recognize if you are going to have technological changes, you are going to have to have some newness, but it seems like it is an extraordinary burdening process each time, and why can we not say—here is a principle that has been operational for *x*-number of years. It has passed all the inspections and licenses, it is proven. The next one and the next one are going to be just like this one.

That is why your word "simplicity" caught my thought process. I wanted to follow up on why don't we do this? Why don't we direct that if we are going to have nuclear power generation in this country, that it have that simplicity, that it have that proven core of technological design?

Dr. BUNCH. Senator, I couldn't agree more with you. It seems to me that one of the ways to make sure that happens is to secure enactment of the legislative proposal of the administration. A new licensing process that would encourage the use of that kind of concept would be a major step toward realizing the benefits of advanced nuclear plants.

Part of the problem has been that there are not new orders at this point in time. We have seen that particular step be very successfully applied in both Japan and Europe. I would expect that at such time as we see a resurgence in demand in this country that you will see continued efforts to bring that kind of plant into being.

Senator MURKOWSKI. Well, there is legislation now, and I gather it is not going anywhere, and I think that is too bad.

Mr. DENTON. I did want to respond to that, Senator. There are a few standard plants in this country which look alike and they tend to operate very well. Wolf Creek and Calloway were a group of four; two plants were canceled but two were finished. Both of those plants are running very well. That was an attempt by the industry at standardization.

Palo Verde 1, 2, and 3 are all cookie-cutter copies of each other and they are operating very well. But what we have is a very competitive industry with four vendors, each trying to market its product. So we try to have requirements for simple, easy to build, reliable, safe plants, and each comes up with a design and so far, while everyone agrees standardization is desirable, industry forces have tended to prevent it from actually occurring.

Senator MURKOWSKI. Thank you, Mr. Chairman.

The CHAIRMAN. Senator Metzenbaum.

Senator METZENBAUM Mr. Meyers, what are the estimates of the number of fatal and nonfatal cancers which will develop over the long term as a result of the Chernobyl accident?

Mr. MEYERS. As a task force, we did not make those kinds of estimates in large measure because we had very limited data on the actual deposition of radioactivity, or its release in the exclusion zone around the plant.

Senator METZENBAUM. Did you send anyone over immediately after the accident to do your own monitoring of Poland, Sweden, the other nation's of Europe, or did you just rely upon whatever information might be available in those countries?

Mr. MEYERS. We actually sent an EPA representative to Poland and Hungary, where he essentially had access to the Embassy and the Embassy grounds only.

Senator METZENBAUM. The Embassy did not actually do a day-by-day count as would be necessary in order to determine the impact, did they?

Mr. MEYERS. We had some there, relatively quickly, within I think, 3 days.

Senator METZENBAUM. You say you had someone there, but there were a number of countries involved, and all they did was to monitor.

Mr. MEYERS. That is right.

Senator METZENBAUM. So that actually, EPA did not send over—you can buy a radiation monitor for about $150, can you not?

Mr. MEYERS. We left the instruments there, so that the Embassy personnel, the scientific representatives could operate them. The initial concern that the State Department had was the health and safety of their employees.

Senator METZENBAUM. What about the 300,000 servicemen in Europe?

Mr. **Meyers**. These are the Eastern bloc countries. We were getting very good data from the Western countries, and the levels that we recorded there were essentially not harmful to human health.

Senator **Metzenbaum**. Have you made no official estimates as to what the potential loss of life will be in Europe as a result of this accident?

Mr. **Meyers**. We have not; not as a task force.

Senator **Metzenbaum**. With respect to your monitoring and the information available, let me read you a statement from the Los Angeles Times. "Some scientists may have further muddied the data by the manner in which they have worked with it. In computing cumulative exposures to radiation in European cities, for example, EPA ignored some of the data because the agency thought the readings were too high. Reports for May 1 in Warsaw, for example, showed readings of both 60 milirems of radiation exposure per hour, and 1.5 million milirems per hour, but EPA discarded the higher figure, a spokesman said, 'Because it didn't fit in with the rest of the data and we think they might have made a mistake.' "

What do you know about that? Did the EPA discard the report of 1.5 milirems per hour and use only the 60 milirems per hour?

Mr. **Meyers**. Senator, I don't recall seeing myself the 1.5 milirems. Based upon the other information I have seen, it seems that it would not have been correct, and what you have suggested may indeed have happened. I will have to check on it. I don't have personal knowledge of it.

[Subsequent to the hearing Senator Metzenbaum and Mr. Meyers submitted the following:]

## Additional Statement By Senator Howard M. Metzenbaum

For clarification, I wish to include in the record a copy of the *Los Angeles Times* article I cited while questioning Mr. Myers of the EPA.

I would like to point out that the radiation levels I quoted to Mr. Myers (60 milirems per hour and 1.5 million milirems per hour) were incorrect. The correct levels were 1.5 milirems per hour and 60 milirems per hour.

However, the thrust of my question to Mr. Myers did not relate to the particular radiation levels cited. Rather, my concern was whether the *Times* article was correct in reporting that the EPA disregared some data because readings appeared to be too high, and whether such an action would be proper.

Los Angeles Times, 5/22/86

# Radiation Reporting Needs Improvement, U.S. Scientists Say

By THOMAS H. MAUGH II, *Times Science Writer*

One clear lesson of the Chernobyl disaster is that current systems of monitoring atmospheric radiation in much of the world are far from adequate and perhaps are not capable of providing sufficient early warning to the public, scientists say.

The main problem is that there are no standard procedures or instruments for measuring radiation and no formal reporting system.

As the Soviet accident has demonstrated, individual countries do their own airborne radiation measurements. And more often than not, they use different types of equipment, monitor for different periods of time, and report results in different units. Sweden, for example, reports readings in "bequerels per cubic meter," France in "microGreys," Britain in "microsieverts per hour" and the United States in "picocuries per cubic meter."

For all these reasons, then, scientists now concede that the actual human exposure to radiation released during the Chernobyl accident may never be known.

"We've been trying to get information about the radiation release and exposures. But it just isn't available," said Roger Ney, executive director of the National Council on Radiation Protection and Measurement.

**Inexpensive Detectors**

This situation could have been largely avoided, according to medical physicist John Gofman of UC Berkeley. "Good radiation detectors are available for as little as $160. A planeload of them could have been on the way to Europe the day after the accident was reported, and we would have had a much better idea of what happened," he said.

Some inconsistency in reported results arose from differences in equipment. Radiologists in Finland noted earlier this week that their system is best because its equipment uses activated charcoal to trap gaseous compounds that may contain radioactive iodine. These compounds are not trapped in conventional filters used by most countries, including the United States. As a result, the Finns estimated, other countries actually detected as little as 15% of the total amount of radioactive iodine present.

The U.S. Environmental Protection Agency acknowledged earlier this week that its radiation monitors do not trap such gaseous compounds. EPA officials conceded that actual radiation levels in the United States were 2½ to 3 times as high as EPA had been reporting. But even the increased levels were well within safety guidelines, the agency said.

Since the Chernobyl accident, individual countries have been reporting their results to the World Health Organization for compilation and dissemination, but some countries have been criticized for apparently being selective in that reporting.

**No Immediate Data**

WHO has no data, for example, from Poland for April 27, 28 and 29, the days immediately following the accident. Most scientists agree that the highest levels of radiation would have been released during the first two days following the explosion.

Data for many other countries during that same two-day period, such as East and West Germany, Austria, and Romania, are also missing. France has released almost no information about radiation levels.

Some scientists, such as Gofman, and some anti-nuclear organizations, such as the Union of Concerned Scientists, think that the countries closest to Chernobyl may have withheld information about exposures during those first two days to prevent hysteria among their citizenry.

Some scientists may have further muddied the data by the manner in which they have worked with it. In computing cumulative exposures to radiation in European cities, for example, EPA ignored some of the data because the agency thought the readings were too high.

Reports for May 1 in Warsaw, for example, showed readings of both 60 millirems of radiation exposure per hour and 1.5 millirems per hour. But EPA discarded the higher figure, a spokesman said, "because it didn't fit in with the rest of the data and we think they might have made a mistake."

That day would, however, have marked the period of highest exposure, and the levels would have been expected to drop sharply later.

Times staff writer Tyler Marshall in London contributed to this story.

June 19, 1986 Committee on Energy and Natural Resources

On page 85 in the hearing transcript, Senator Metzenbaum, in a quote from the London Times, stated EPA ignored some of the data because the Agency thought the readings were too high. He asked Mr. Meyers to respond.

— EPA's response follows:

As part of the Federal Task Force's response to the Chernobyl accident, EPA's Office of Radiation Programs made extensive efforts to obtain credible radiation data from foreign countries and to make that data available to all interested parties. EPA and other Federal agencies requested and obtained data through contacts in the international scientific community, the World Health Organization, the International Atomic Energy Agency, and through formal requests of governments via the State Department.

The following quality assurance and reporting rationale were applied to all data:

o Data must have originated from a reputable health organization.

o Data would be reported as received if there were no obvious errors.

o All values would be checked for errors in data entry.

o Extreme or conflicting values would be reviewed and corrected, if identified as erroneous.

This "real time" reporting rationale allowed EPA to make the data available for timely dose and risk calculations while still assuring reasonable quality. However, a few situations were encountered which required delays in reporting data and/or revisions of reported values:

o Telex reports identified direct exposure values in excess of 100 Rads per hour (R/H). The telex printed in upper case only and there was a space just before the R/H. A second telex identified the values as MICRO R/H (µR/H). The $(\mu = 10^{-6})$ had not printed in the first telex.

o Values of 1,000 mR/H (extremely elevated but possible) were reported by EPA, but later corrected to 1,000 µ R/H when that same country identified normal background levels as 10 mR/H. A background or ambient level of 10 µR/H is what would be normally expected for that country. The country was using an m instead of a µ to indicate micro.

o Values of 1.5 and 60 mR/H were reported by one country for the same date and location. A spread of 1.5 and 60 mR/H is unlikely; however, this situation could exist due to an extremely localized rainout of radioactive materials. The country later retracted these values due to large errors in measurement techniques and reported the highest value ever reached for that location was 60  R/H. The values were removed from the EPA report.

We have discussed our reporting rationale with a number of radiation professionals (including persons in the NRC, DOE, and Dr. John Gofman). Dr. Hofman has indicated that he fully understands our rationale in approaching the data reporting problem. Both DOE and NRC also support EPA's approach..

Senator **Metzenbaum**. Would that disturb you if somebody made a decision just to disregard the higher figure, particularly in view of the fact that that is the day when it was the highest level of exposure and obviously it would have been expected to fall after that, shortly after the accident when the winds were blowing in that direction, you would expect it to be at the highest level—for an EPA official to just say "we just discarded it."

Mr. **Meyers**. Not necessarily. You may recall several weeks after the accident there was a report of an elevated reading in Finland, and it later turned out that the instrument was faulty.

Senator **Metzenbaum**. That is not what I am asking. Certainly there are times when you get information and the information is faulty. This isn't what was said. "Because it didn't fit in with the rest of the data, and we think they might have made a mistake."

Now the scientists with whom I have spoken since the accident have indicated that scientists never disregard any particular element and they attempt to explain why it is there, or if indeed it is a mistake, they try to find out whether the equipment was faulty or what. But they just don't throw it out the window, as has been suggested by the EPA spokesperson.

Mr. **Meyers**. Again, I am not familiar with that. I will have to look into it when I get back, and I will get back to you for the record.

Senator **Metzenbaum**. Does the Government expect to have an official estimate as to what the number of deaths that may be anticipated, as well as the number of cancers that may be anticipated?

Mr. **Meyers**. As I said earlier, the task force itself did not do that kind of analyses and since the task force has disbanded, unless there is a specific request made to, for example, the Health and Human Services Agency, I suspect it will not be done.

Senator **Metzenbaum**. Is the EPA in a position to make that determination?

Mr. **Meyers**. We would have difficulty without getting more accurate data from the Soviet Union to know explicitly how to make the calculations in the Eastern bloc countries, for example.

We do have data in the Western countries, and I suppose that one could postulate certain scenarios and make those calculations. One of the aims of the task force was not to conjecture and postulate and put together different kinds of scenarios because we felt it might be false and alarming.

Those calculations clearly can be made; what their validity is, is not clear.

Senator **Metzenbaum**. Well, Dr. Goffman is in touch with the EPA, and I would assume many other scientists are in touch with EPA. He has made an estimate of 320,000 deaths, as well as 320,000 additional cancers. I would guess that other scientists would have their own evaluation.

Is it not a responsibility of Government to indicate to the American people what the estimate is and what the evaluation is as to the impact of the Chernobyl accident?

Mr. **Meyers**. Senator, I have not seen Dr. Goffman's analysis, nor the others. If we had them, we could certainly review them and have it go through a peer review process to determine the validity of the analysis.

As of this time, again, it is not at all clear to me what obligation the United States has to do an analysis of the number of deaths in the Soviet Union?

Senator **Metzenbaum**. Is it that maybe the Government does not want to find out?

Mr. **Myers**. No, not at all.

Senator **Metzenbaum**. Maybe there is a concern that toes might be stepped on? Even if his figures are wrong—assume they are high—but it would be very disturbing to the American people if they knew that the Chernobyl accident will probably result in *x* number of deaths and cancers. Are we not entitled to that information?

Mr. **Denton**. Senator, perhaps I can help a little on that. In the forthcoming IAEA meeting with the Soviets, it is my understanding that there will be coverage of the consequences of the accident, and I understand the World Health Organization will be involved, and another U.N. organization which specializes in radio effects will be involved. I would expect those two medically oriented groups would be the ones who would, with Soviet cooperation, document what the consequences of that accident were on the Soviet people.

Other countries, such as Sweden, are actively doing the kind of thing that you are talking about now; the countries who are most effected are doing it, and I would suspect that somewhere down the road the World Health Organization will probably issue a report that brings together all the biomedical information on what the consequences were.

Senator **Metzenbaum**. When do you think that might be?

Mr. **Denton**. I think it will be at the earliest, late this year, after the Soviets have provided the necessary information.

Senator **Metzenbaum**. I think you are both touching upon the concerns that I have. Ms. Walker has a comment, but one of the concerns I have is that, as that article that Senator Bumpers was reading indicated, Three Mile Island fades off into the distance and people forget about it, and don't concern themselves, and they are not nearly as alarmed now. Chernobyl is on the front pages for a while, and it fades. In 3, 6 or 9 months from now, it will be but a vague memory.

I think that what bothers some of us is the fact that there is going to be a task force and there is going to be a meeting of the World Health Organization and a meeting of the IAEA, and there is going to be this and that, but the fact is, some things can be determined on a much more expedited basis, and although there might be an inability to give the exactitude that is wanted, the fact is that there ought to be some knowledge as to how many lives were endangered, how many cancers will result from Chernobyl, and I believe that what we get from the people at the NRC, EPA, and the other Energy Departments is just sort of a laid-back attitude.

We put things in the Embassy and we are checking into it; no sense of urgency, no sense of real concern. I know I, as one individual, am concerned about the safety of my grandchildren. I am concerned when they are living around nuclear reactors, and I do not feel a sense of urgency.

I think the article that Senator Bumpers was reading had another phrase in it. There is a willingness to accommodate industry wishes and a reluctance to take a strong and aggressive role through regulation. There is a misplaced sense of optimism, even to the point of ignoring the messages we are getting from the operating experiences of the plant.

I think these are the things that concern us. Ms. Walker, did you have something you wanted to say?

Ms. WALKER. Yes, if I could. I might be able to answer some of your earlier inquiries. Picking up your last point, we were very concerned; as soon as a day or two after the accident was made known to us, we were part of the offer of assistance that was made to the Soviet Union.

My office personally assisted in drafting the cable that went over, offering both monitoring and health assistance because we had the expertise and the ability to be a part of it in a meaningful way. As you know, that offer was rejected. We have made other offers since, and I believe even as we meet here currently, we have experts from our national laboratories that are over at the Embassies, providing assistance to members of the U.S. Embassy there in the Soviet Union in terms of monitoring and in terms of explaining to them what we know, and what the dangers are and that sort of thing.

In addition to offers of health and environmental research, the Department of Energy, has established a task group of scientists that are charged with addressing the assessments of the health consequences in exposed populations, and validating the predictive models.

Of course, the health assessment which is designed to produce exactly the kind of information you are interested in is necessarily reliant upon information of the characteristics of the radioactivity that was released, as well as the amount of the doses received. We do not have an independent way of gathering this information, short of what the panel has expressed to you.

Obviously, we are relying on the Soviets to give us information we can't get from neighboring countries or from our own monitoring at the Embassies. We are hopeful to get this information, but we have scientists already committed to this effort. I am not saying they are waiting. They are taking what is known and they are beginning their review.

It will of course be more accurate as more accurate information is made available to them.

Senator METZENBAUM. I would like to ask each of the panel members to submit to the committee for the record their estimate of the number of fatal and nonfatal cancers that will result from Chernobyl. I am certain that there must be some evaluation being made on that subject and I would like to ask each of them to submit that.

The CHAIRMAN. The question has been submitted to each of the witnesses for their response in writing. We will appreciate whatever response you will be able to make.

Mr. **Meyers**. Mr. Chairman, may I make a suggestion? One of the things the task force tried to do was present a uniform Federal Government position on the Chernobyl incident. We had various groups set up to do certain things. I think this was within the realm of the Health and Safety Group that we did set up. It does have representatives on it from all of the Federal agencies, and rather than get several different responses, I think it might be more useful if those agencies worked together and provided you a single response if that is acceptable to you.

[EPA's response follows:]

It is premature to begin an assessment of the health impacts of the Chernobyl accident until more complete data are available, particularly from the U.S.S.R. When more data are available, it is expected that an international group of scientists, perhaps under the auspicies of the United Nations, will perform such an assessment.

Senator **Metzenbaum**. I would be satisfied with that if I got a specific response. If not, I would like each of the agencies to respond.

Ms. **Walker**. I think, too, Senator, if what we are able to provide you with—and I don't know this for certain—now is an indication of the on-going assessments that are hopefully going to lead to more specific information, it might be helpful to you to have the individual agencies respond.

Senator **Domenici**. Mr. Chairman, on that point?

The **Chairman**. I think the Senator's time has expired.

Senator **Metzenbaum**. As I understand, you would rather have individual responses?

Ms. **Walker**. I don't want to preclude the EPA's suggestion; that might be helpful. All I am saying is that I don't know if we can give you specific answers at this time, and if we can't, we will certainly provide you with an assessment of what we are doing.

Senator **Metzenbaum**. That is fine.

[DOE's response follows:]

## Material for Health Consequences Questions: Hearing before the Committee on Energy and Natural Resources

In early May, the Department of Energy's Office of Energy Research established an Interlaboratory Task Group on Health and Environmental Aspects of the Soviet Nuclear Accident. One charge undertaken by the Task Group was to carry out an assessment of the health consequences in exposed populations. The health assessment subgroup has proceeded to collect data and develop information required for the assessment. This includes information on: the source term, i.e., the total amount and type of radionuclides released as a function of time; atmospheric and terrestrial transport of material, and uptake into plants, animals, and the human population. Calculation of whole body and organ radiation doses then provides the basis for an assessment of health consequences.

The subgroup is completing an initial estimate of population dose resulting from the Chernobyl accident. At this time, the uncertainty associated with the dose estimates is very substantial. This derives from uncertainties in the pattern of radionuclide deposition over the earth's surface, which is highly influenced by rain fall, uncertainties in the actual uptake of radionuclides by the exposed population, and uncertainties in the source term for which no definitive information is available. Nevertheless, preliminary dose estimates indicate that exposures in Europe were sufficiently low that no demonstrable health effects are likely to be expected there. A report by the Department's health assessment subgroup is expected within the next two months. We will be happy to provide a copy of the report to the Committee when it is available.

The health assessment subgroup has also established a close working relationship with international organizations such as the Commission of European Communities, and the World Health Organization (WHO). This will enable intercomparison of parallel efforts to obtain dose estimates and will assure a comprehensive and unified assessment of human health consequences. The WHO recently held an international meeting and expects to have a report by late summer on the consequences in Europe of the accident. A global assessment is planned by the United Nations Scientific Committee on the Effects of Atomic Radiation which we understand will be included as a specific annex in their 1988 report.

The CHAIRMAN. Senator Domenici.

Senator DOMENICI. On that last question, so that our distinguished friend from Ohio is not back here in 3 weeks when they submit their answers, to make sure we understand—we don't want a bunch of guesses. If they don't know, because there is not enough information—are they not permitted to tell us that? We do not want somebody to guess, and tell Senator Metzenbaum 100,000 to 150,000, or so.

The CHAIRMAN. I would suggest to the Senator from New Mexico that if indeed the witnesses feel they are incapable of answering the question, that is what their answer will have to be.

Senator DOMENICI. I thank the chairman. I would appreciate the opportunity to ask a few questions.

I was listening here and two things come to my mind. Would the Senator from Ohio stay.

Senator METZENBAUM. There was a Judiciary Committee hearing I was trying to get to, but for you, I will wait.

Senator DOMENICI. I greatly appreciate it. I am not sure you will when I am finished.

But let me say, the first thing that came to my mind as I listened when humankind first rubbed some sticks together and started a fire, I am grateful that we did not have either this committee or the Nuclear Regulatory Commission around, because I guarantee you, if they had a slight bit of clairvoyance and a little bit of computer capability, we would be frozen to death, but we would not have had the fires we have had.

Having said that, let me say, I really do not appreciate at all the insinuation from my good friend from Ohio that our Government, represented here by these people, are trying to hide environmental facts about Chernobyl.

Senator METZENBAUM. I was only quoting from one of the members of the Commission.

Senator DOMENICI. I just do not believe it. Not only do I not believe it, but let me tell you, I believe they are just as interested in the information about Chernobyl, and TMI, as they are about the effects of coal-burning plants in the United States on the health and welfare of our people.

I believe that they are just as interested and doing just as good a job, or just as poor a job, evaluating the health effects on American people from the pollutants coming out of the smokestacks that are burning coal as they are about nuclear. I believe your people in Ohio are just as interested, and if they are not, they ought to be.

If we are going to insist on a new study, I am going to ask that they do a study about the effect of the failure of the coal-burning plants in the State of Ohio to yet today meet the ambient health standards of the United States.

Senator METZENBAUM. I have no problem with your request.

Senator DOMENICI. I think we ought to do that.

Senator METZENBAUM. I think that whatever the Senator from New Mexico thinks we should do, he ought to do. That is the Senator from New Mexico's decision.

I am much more concerned about the potential problem——

Senator DOMENICI. Mr. Chairman, I would ask that the Senator from Ohio, as I did for him, be permitted to make my statements and ask my questions. If he would like me to yield, he has been around here a long time, and I would be very pleased to do that.

The CHAIRMAN. The Senator from New Mexico has the floor.

Senator DOMENICI. Now, having said that, I would also suggest that the distinguished Senator from Arkansas arrived just at the right time, because I remember he and I served——

Senator METZENBAUM. I thought this was on nuclear energy, not on the Senators from Arkansas and Ohio.

Senator DOMENICI. I wanted to say how he and I first got interested in the greenhouse effect. We were kind of young Senators here and they gave us a great job, if you recall. We were on a subcommittee of one of the committees that had charge of NASA. That committee was going to be abolished, so they gave us this little job.

It turned out we were studying the effect of those sprays on the possibility of cutting the sunlight and it would cause perhaps greenhouse, and all these other things. From that has come a genuine interest on his part. I am only raising this question because it appears to me that we ought to make sure that the American people understand that while there are risks, and great risks in nuclear energy, and the Senator from New Mexico is not trying to minimize them, and certainly Chernobyl is a good lesson—and let me suggest in a moment I will talk about what I think the lesson is—that anything in the area of producing energy for the American people in electricity has risks.

If we want to talk about zero risk accident in nuclear, we ought to talk about zero risk in coal burning. I submit that the evidence would indicate today that more of the American people have died, been injured, got black lung from those aspects related to coal-burning powerplants—because you cannot burn it without digging it, you cannot dig it without getting black lung—and we have not had one death we have proved yet from nuclear energy in this country, and we are here talking about zero risk, some kind of—America is negligent, we do not care, we are doing all these things wrong—and I just do not believe that.

Now let me ask all of you; if the Soviet Union wanted to export one of those plants like the one that had the accident to the United States of America, as inefficient or efficient as the Nuclear Regulatory Commission is, and I do not know which one you want to buy, and since, even though they cannot talk to each other because if they do they violate the law—they have to hold a public meeting—given all those, could that powerplant be built in the United States today?

Mr. DENTON. I would like to answer that, Senator. We came across a study that was done 10 years ago by a British company, and at that time, they concluded the plant could not be licensed in the United Kingdom I think it is important to realize that study was done pre-Chernobyl, therefore it was not biased by the accident. But just reading the contents of that study, I would come to the same conclusion; that plant could not be licensed in the United States.

Senator DOMENICI. Now, I want to ask you one other question comparing, just for purposes of whether we are doing a pretty good job—that is all I just want to try to establish here. Both these, TMI and Chernobyl, had a very serious accident. It was core-related; is that correct?

We assumed there was a core meltdown at TMI, and we assumed there was a similar one at Chernobyl, do we not? Let me ask you: One mile from TMI, what was the curie count, if you recall?

Mr. DENTON. The numbers I do recall were, on iodine-131, there were 15 curies released from TMI over the course of the accident, and 50 to 60 million curies of iodine-131 released at Chernobyl. Some of the same comparisons would work for the noble gasses, also.

Senator DOMENICI. Let us have the numbers one more time. At the same distance, we are measuring for the potential radioactive effects that might occur on living things, and one of the ways we do is to measure what?

Mr. DENTON. The total amount of iodine-131 that was released. Iodine is one of the most hazardous isotopes in the reactor. At TMI, 15 curies were released; at Chernobyl, 50 to 60 million curies of the same isotope.

Senator DOMENICI. Now, let me ask you, what is the principle reason that they had 15 and they had the millions that you just described?

Mr. DENTON. I think the principle difference would have to be attributed to the reactor pressure vessel and the reactor containment that worked at TMI, and whatever enclosure the Soviets had provided was ineffective and permitted the release of essentially all that isotope.

Senator DOMENICI. All right. Now we use this word containment, and sometimes words that have very, very explicit meaning seem out there to take on some scientific meaning. Containment is the right word, is it not? We have a light water reactor that could work all by itself with what it has, only we put a container around it so that if anything gets out it gets hooked up in the container. Is that a valid description of what containment is?

Mr. DENTON. Yes, sir. Containment are those large, strong buildings that are typically shown as housing the reactor. We have required them in this country since the earliest reactors were licensed.

Senator DOMENICI. And they do not have one of those on these plants? They do not have that kind of containment on the plant that had the accident, or on almost of their civilian reactors?

Mr. DENTON. From the best we can tell, they had paid little attention to accident mitigating features of any kind; containment, emergency safety features, all the safety features, up until fairly recently. It does appear that when they began to export reactors, they attempted to upgrade their standards to Western style standards.

But this reactor, obviously, did not have a Western style containment building around the reactor core.

Senator DOMENICI. As a matter of inquiry, other than their satellite nations, which I do not assume buy voluntarily, how many countries have bought nuclear reactors from the Soviet Union for civilian use of the kind that are at Chernobyl? Freely and open in the market.

Mr. **Denton**. I do not think they have sold any of the Chernobyl type outside the U.S.S.R. They have sold a different type of reactor, one that looks more like a United States light water reactor, but the first country that bought one, Finland, insisted on Western style containment. They bought that containment from Westinghouse.

Senator **Domenici**. Thank you, very much.

One last question: Civilian nuclear reactors in the United States, owned and operated, produced by civilian companies, operated by powerplant companies, whether they are privately owned or cooperatives, do they produce as a byproduct of the activity plutonium that can be used for military purposes? U.S.A. I am talking about. Civilian-run light water reactors. Do we have any that are there to produce plutonium for the military of the United States?

Mr. **Denton**. None are designed to produce plutonium. As a byproduct of operating, they do produce plutonium isotopes in the fuel, and that plutonium then undergoes fission just as the uranium atoms undergo fission. So at the end of life on a commercial reactor core, there is plutonium actually in the fuel.

Now, whether its concentrations are such that the Department of Energy would consider it useful in a weapons program or not, I will have to defer to them. But the plants are not designed to produce weapons from plutonium. But any time you put uranium-238 in a reactor core, it does produce plutonium.

Senator **Domenici**. Now flip that over; what about theirs?

Mr. **Denton**. It is fairly clear this reactor had its origin as a weapons production reactor. I think that is why it is designed the way it is. They apparently adopted it to try to turn it into a power producing reactor.

They did have problems with reactivity coefficients and its dynamic behavior. We do have information showing that they changed the fuel concentration recently in an attempt to make the reactor more stable. I don't really know how to answer the question for all of their type of reactors, but looking at the isotopes that we did detect from the accident, it does not appear that it was operating in a weapons producing mode.

Senator **Domenici**. My last question, is not the model and make up, behavior of the Soviet reactor that we are talking about here, such that the higher the capacity the more you try to pump out of it by way of heat, the more plutonium it produces. Is that not correct? So if you want plutonium and you are interested in it, that means you maximize it because it produces more when you maximize it. Is that correct?

Dr. **Bunch**. I don't believe that is correct, Senator. I believe in fact what has been done in the last couple of years with that particular design at Chernobyl is to maximize it for power production.

Senator **Domenici**. I understand that that is what they have done. But I am asking, in its design, without modification, without attempt to make it do otherwise, does it not produce more plutonium the higher efficiency you try to pump into it? I could be wrong. I just read that someplace.

Dr. **Bunch**. I believe that you are mistaken, Senator. At the power level given, what you wind up doing is burning the fuel longer, as in U.S. light water reactors, and that decreases the quality of the plutonium that is in the plant.

Senator DOMENICI. Thank you, very much.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you, Senator Domenici.

Senator Melcher.

Senator MELCHER. Mr. Denton, the staff of the Commission has estimated that out of the 100 nuclear plants in this country, there is a 45-percent chance of a core meltdown. Just so we understand what that likelihood is, does that 45 percent mean that you flip a coin 100 times, and 50 times it is going to come up heads? What does it mean?

Mr. DENTON. I don't think the number itself is too meaningful.

Senator MELCHER. What does it mean?

Mr. DENTON. It is assuming that all the plants have about the same management capabilities and maintain their plant at about the same level, and have, good drug abuse programs in place, and that therefore, you could treat all the class of reactors as cookie-cutter imitations of each other. That you truly have a random statistical type basis.

What that number was based on were the 15 or 16 probablistic risk studies that have been done since TMI, taking sort of the average number and assuming that the same number applies to all the plants, and that we are not effective in trying to reduce the probability through our regulatory systems and other pressures that we bring on the utilities.

It is my goal to try to reduce it at individual plants as low as we can.

The real secret at preventing, accidents, I think——

Senator MELCHER. What does the 45-percent chance mean? My next question will get into how safe people feel about nuclear plants. But this is one item and if it means 50–50, that is what I am asking. Does it or does it not?

Mr. DENTON. Let me tell you what it does mean and how we got it. We originated an average number for the probability of a TMI-type event based on analytical studies. That number turned out to be about 1 chance in 10,000, roughly.

If you assume that we have 100 plants, and you run 20 years, and you run through the math, you can come up that somewhere in the U.S. population of reactors, in the next 20 years, there would be a 45-percent change of another accident such as TMI occurring.

Senator MELCHER. Did the staff suggest that it was a core meltdown, or the chance of one occuring? Were they not looking at a chance of a core meltdown?

Mr. DENTON. No, we were looking at a TMI-type occurrence.

Senator MELCHER. But not a core meltdown.

Mr. DENTON. That number does not assume that containment would fail.

The CHAIRMAN. Would the Senator yield?

Senator MELCHER. Yes, I would be glad to.

The CHAIRMAN. There was a core meltdown at TMI, was there not?

Mr. DENTON. Yes, partial.

The CHAIRMAN. Partial. All right.

Senator **Melcher**. To clarify your answer, so that I understand it, it was that this 45-percent chance or probability did not include a core meltdown any worse than what was at TMI.

Mr. **Denton**. It included a complete release of fission products to the containment, but it did not include a containment failure. Our plants are designed with containments so that the chances of a core meltdown in the reactor vessel leading to a Chernobyl-type release is low. That is the function of containment.

Senator **Melcher**. How long is it?

Mr. **Denton**. It varies. All our containments have substantial margins, but some are——

Senator **Melcher**. No, I mean, what were the chances?

Mr. **Denton**. At TMI the containment did not fail. So that is one statistical data point there, and the studies done afterwards show that that containment was designed as such that there was very little chance of it failing under a lot of circumstances.

We litigated this question at Indian Point, and the answer for that containment, which was the most populated site in the United States was a few percent chance that the containment will fail, given you have a core meltdown.

Senator **Melcher**. A few percent, like 5 percent?

Mr. **Denton**. I would say less than that; 2 or 3 percent.

Senator **Melcher**. Dr. Bunch, regarding the question of the public confidence in safety, has not the design of the plants been sort of regulate as you go?

Dr. **Bunch**. I think it is fair to characterize the emergence of the plants in the 1960's as design as you go. The technology was developing, and the powerplants went in in a fairly short period of time. Power ratings went from several hundred megawatts to above 1,000 megawatts.

There was a period of development, and I think the regulatory process was in a very major period of growth in that period of time, so there was, in response to this developing commercial industry, a regulate as you go activity.

Senator **Melcher**. Is that not part of the reason for the public alarm, that the plants are being designed as you go, and then regulate as you go? What percentage of the 100 plants that are in operation would be affected by that design as you go and regulate as you go feature?

Dr. **Bunch**. I think that the message I would convey out of that is, first, we saw the introduction of technologies which I believe to be fundamentally sound.

Senator **Melcher**. How many of the plants are design as you go and regulate as you go?

Dr. **Bunch**. The point I was going to get to, as Mr. Denton described, for most of the early period of the introduction of these commercial plants, they were customized units and not standardized. So there was little opportunity to look at units that were going to be fully subjected to resolving all the safety problems before they actually proceeded to construction.

For the last several, we heard a comment about Palo Verde, the SNUPPS units, there was much more a degree of standardization and there was a greater backlog on the part of the regulatory staff and the designers about what was involved in those particular products.

So, the short answer is, most of the plants that we presently have today are in the design-as-you-go/regulate-as-you-go kind of mode.

Senator **Melcher**. That would be like 90 out of 100?

Dr. **Bunch**. I don't think that is an unreasonable estimate, sir.

Senator **Melcher**. 90 out of 100. The Commission staff says that there is practically a 50–50 chance of another TMI accident occurring. Is this not interrelated with the same concern that the public has, or the apprehension they have, with these plants, over the design as you go aspect, as they are being constructed, and after the design was figured out, what to regulate them—as you go—to prevent any failure. Does not this therefore cause for alarm?

Dr. **Bunch**. My view is that the design of the plants on the part of the designers, and the review of those plants on the part of the regulators, did pay a good fair measure of attention to the fundamental criteria under which those designs would be developed. A fair measure of attention was given to making sure that the way the plant was going to be laid out and engineered, was going to be sound. The regulate-as-you-go part of it came when operating experience came up, such as on water hammer, or materials failures, or equipment wasn't behaving exactly the way that people had hoped and intended, there needed to be accommodations and new ways of dealing with those in design, and new ways of satisfying regulatory solutions.

That particular way of dealing with after-the-fact experience has, I think, caused some concern on the part of the public. It is on that ground, I think, that what Mr. Denton was talking about, to get past that and show that we have resolved those problems is going to be very helpful.

Mr. **Denton**. Senator, I need to be sure I clarify one point. As a result of those 18 or so probabilistic risk studies that were done, many changes were made in the plants because they did identify vulnerabilities and areas that contributed to risks I think the most recent commission tabulation, where they go back and look at the plants as they exist today, and are being operated, the same calculation gives an industry average severe core damage frequency of about 6 chances in 100,000.

So, I think today if you ask the Commission about the 45 percent, the answer you will get is 12 percent. It sounds like it is pencil sharpening, but what it really is is that the vulnerabilities identified in the earlier studies have been corrected, and therefore, as those improvements are made in the plants, the probability of an accident gets lower and lower.

The Commission is in favor of standard plants. There is an effort going on with EPRI, the Electric Power Research Institute, in which we would get the complete design before we issued any license. The plant would be designed with a safety goal in mind, so that that would be a part of the design. That has not been required as part of our system up to now.

Senator **Melcher**. Mr. Denton, you mentioned drug and alcohol programs for the people in the plants. What is the percentage of human error then, leading to the risk of a Three Mile accident or some other similar accident?

Mr. DENTON. I don't have an exact number, but you find in every event we looked at, human error plays a significant role in it. It is not just a piece of equipment failing and then——

Senator MELCHER. So then it is 100 percent.

Mr. DENTON. I would say human errors have been involved in every significant accident in the United States.

Senator MELCHER. That is right, so it is 100 percent.

Mr. DENTON. And that whole area has taken a lot of our attention to try to upgrade the qualifications for people who operate the plant, and programs like drug abuse, to be sure they can perform in an emergency.

Senator MELCHER. For those people who design and engineer the plants, I suspect that the answers we have received, a 45 percent likelihood of a TMI accident, has diminished because you have taken some actions that improve it. Therefore, the 45 percent found by the staff studies earlier is lower.

I point out that since human error is involved in 100 percent of those cases, it is no wonder the public has some concern.

Mr. DENTON. One area that I think has made a big difference is the use of simulators. Pre-TMI there were very few simulators used in the nuclear business. Today there are about 70 or 80 simulators, which is a reconstruction of the reactor control room, and you can put the people through their paces with the worse imaginable types of things going on and make sure they know how to respond.

In a normal reactor, if operated properly, you get very few challenges, so the operators tend to go stale, and I think the introduction of simulators is ultimately going to really pay off as an improvement.

Senator MELCHER. Thank you, very much, Mr. Denton. Thank you.

The CHAIRMAN. Senator Bumpers, I think you indicated you had one or two more questions. We can probably crowd those in before we have to recess for the vote.

It will be my plan to entertain those questions, then release this panel, recess the committee for the vote, and return to hear the five witnesses on the second panel.

Senator BUMPERS. Mr. Chairman, I thank you very much for your indulgence. I just want to say that I would like also to submit some questions for the record to this panel.

The CHAIRMAN. All Members will have that privilege.

Senator BUMPERS. Mr. Denton, on June 9, 1986, you are reported in a publication called Inside NRC, in an interview, you said regarding General Electric's Mark I containment:

> I don't have the same warm feelings about GE containment as I do about the larger dry containments.
>
> Harold Denton, director of NRC's Office of Nuclear Reactor Regulation told utilities officials, "There has been a lot of work done on those containments, but Mark I containments, especially being smaller with lower design pressure—and in spite of the suppression pool—if you look at the WASH 1400 reg safety study, you will find something like a 90 percent probability of that containment failing."

Now, the GE officials there pooh-poohed that and took strong exception to what you said. The independent information I have is that you are dead right about that. Have you changed you mind for any reason?

Mr. **Denton**. No. I have called in the owners of the Mark I containments.

Senator **Bumpers**. There are 25 of those in this country, as I understand it; boiling water reactors, with that containment.

Mr. **Denton**. As I mentioned earlier, the containments have—they are all designed for the design-basis event, but they vary with regard to their capability to withstand the core meltdown. The case I mentioned, Indian Point, is a strong, big containment which is probably the most likely to perform well.

The Mark I is the smallest of the containments that exist. I have met with all the owners. The owners insist that the new research results that are available indicate that their containment is no more likely to fail than the big ones. I said it is time to prove it; that our old studies showed that it was very vulnerable to failure. There are ways in which that containment can be improved and brought up to high standards so that the probability of early failure is low.

They have accepted that challenge and I look forward to closing that issue with those owners.

Senator **Bumpers**. I want to thank you. You go on to say:

> There is a wide spectrum of ability to cope with severe core accidents in GE plants, and I urge you to think serious about your ability to cope with such an event if it were to occur at your plant.

And, then:

> Questions concerning whether the Mark I containment would withstand a severe accident have taken on new importance following the Chernobyl accident, Denton said. And in response to the political climate following the accident, industry and the NRC should focus on the integrity of Mark I containment rather than continuing to debate the probability of severe accidents.

I applaud you for saying that, and I will certainly applaud you if you will continue to pursue that in a very vigorous way.

Mr. **Denton**. Thank you, Senator.

Senator **Bumpers**. Mr. Chairman, I want to ask unanimous consent that this entire report be inserted in the record.

The **Chairman**. Without objection, so ordered.

[The report referred to follows:]

### Denton Urges Industry to Settle Doubts About Mark I Containment

NRC's top safety official has urged the U.S. nuclear industry to give top priority to settling lingering uncertainties about the ability of General Electric's Mark I containment to withstand a severe core melt accident.

"I don't have the same warm feeling about GE containment that I do about the larger dry containments," Harold Denton, director of NRC's Office of Nuclear Reactor Regulation (NRR) told utility officials. "There has been a lot of work done on those containments, but Mark I containments, especially being smaller with lower design pressure—and in spite of the suppression pool—if you look (at the) WASH (1400) reg safety study, you'll find something like a 90% probability of that containment failing."

Denton also told industry leaders gathered last week at an Electrical Power Research Institute conference at Brookhaven National Laboratory that some plants with Mark I containments may not be prepared to deal with a severe accident that might lead to containment failure. "There is a wide spectrum of ability to cope with severe core accidents in GE plants, and I urge you to think seriously about your ability to cope with such an event if it were to occur at your plant," he said. There are 25 BWR units with Mark I containments in operation in the U.S., according to a 1984 study done for NRC.

Questions concerning whether the Mark I containment would withstand a severe accident have taken on new importance following the Chernobyl disaster, Denton said. And in response to the political climate following the accident, industry and the NRC should focus on the integrity of Mark I containment rather than continuing to debate the probability of severe accidents.

"We can argue about the probability of severe core damage for a long time," Denton said. "I think the political climate is such that people are willing to concede that maybe they (severe accidents) will happen now and then at U.S. plants, despite the best efforts of everyone. But they want to know it won't turn into the Chernobyl-type event."

For that reason, Denton said, NRC will give "a lot of attention" to industry efforts concerning the integrity of Mark I containment. He said Idcor (Industry Degraded Core Rulemaking Program) studies on ways to "be sure these containments don't fail early due to overpressurization ... should really be top priority." To protect Mark I containments from the overpressurization "would require positive ways to vent and filter before you get a high pressure buildup," Denton added.

Denton said in an interview following his address that the message he was trying to convey to industry was: "If you want to find something to go look at that has a high payoff, that (Mark I containments) is not so bad."

The notion that a Mark I containment might fail in the event of a severe accident was strongly disputed in an earlier address to the conference by an official from Philadelphia Electric Co., who said that that perception has resulted from computer models "driven by silly little assumptions."

"The perception of the Mark I problem is totally unwarranted," said Richard Diederich, who is in charge of probabilistic risk assessments for Philadelphia Electric. Inaccurate assumptions used for the sake of conveninece by both the NRC and Idcor in modeling accident sequences and the risk of containment failure led to the perception, Diederich said. "But it's not true."

GE, in a statement released after questions were raised concerning its containments following the Chernobyl accident, said: "Attacks on the safety of the containment system used with GE reactors represent a rehash and exploitation of items that were raised and then resolved eight years ago ... GE reactors are safe." *-Brian Jordan, Brookhaven National Library.*

The CHAIRMAN. If there would be no further questions for this panel, I wish to thank each of you, and I wish to thank the members of the second panel for their patience. The committee will stand in recess and will return in just a few minutes.

[The committee was recessed.]

The CHAIRMAN. The committee will come to order.

Our second panel in the hearing today, Dr. Schulten, director, Institute for Reactor Development, Nuclear Research Center, Julich, Germany; Mr. John Taylor, vice president, nuclear power division, EPRI; Mr. Zack Pate, president, Institute of Nuclear Power Operations; Dr. Richard Dean, senior vice president, GA Technologies, Inc.; and Mr. Jan Beyea, senior staff scientist, National Audubon Society.

We will start with Dr. Schulten, and as I said to the other panel, your entire prepared statements will be placed in the record. You are invited to summarize the statements in whatever manner you wish. Dr. Schulten? We do thank you very much for your willingness to appear here.

## STATEMENT OF DR. RUDOLF SCHULTEN, NUCLEAR RESEARCH CENTER, JULICH, GERMANY

Dr. SCHULTEN. Thank you. Mr. Chairman, may I introduce myself. My name is Schulten. I work in the Nuclear Research Center, Julich, which is located near Cologne, in Germany, and which is one of the two big nuclear centers in my country.

I am working there as a leader of the HTR development since more than 20 years. At the same time, in the last years, I am also the vice president of the Technical University in Aachen.

I was in charge of the construction of the AVR, the first high-temperature reactor in Germany, and I was also the project leader for the planning and development of the second high-temperature reactor, a plant of 300 megawatts electrical.

The German HTR Program now is going on since more than 20 years. The main goal of this development is "Reactors with Passive Safety."

Since about 20 years, we have the first reactor, the AVR, with 15 megawatts electric, and 950 degrees C in operation, quite successfully. Since several months, the second reactor has been in startup operations.

In the 20 years development program, a large number of experiments have been made. The most important are fuel element tests, safety experiments, tests for corrosion, earthquakes, and concrete vessels.

A large number of physical calculations and safety analysis of this reactor type have been made. The safety analyses have been proved and agreed by licensing authorities. Also, a lot of experiments and studies have been made for the application of nuclear process heat for the chemical industry, oil recovery and coal refinery; up to now about 5 billion deutsche marks, including the construction of reactors, have been spent in our country.

Two supplier companies are bidding for small HTR reactors, and a 500-megawatt electric plant is in the planning stage.

Now, to the accident at Chernobyl. It is a big quantity of zirconium of more than 100 tons and it is moderated by graphite. About 1,700 vertical channels are in the reactor. This is a system of a large number of almost independent elements which must be controlled each by engineering safeguards. The facts which we know are not clear enough to say the exact reasons for the accident, but it is sure that the accident started with a chemical explosion of hydrogen which was created by the very fast reaction of zirconium with seam. Our own physical calculations of the nuclear core show in agreement with data from the literature that the core is rather unstable, because the reactivity and power increases when water is lost and when the temperature of the moderator is going up.

The so-called xenon oscillations depending from power and temperature distribution makes controlling of this reactor even more complicated. Therefore, it is not surprising that there has happened a nuclear excursion.

The zirconium-steam reaction was a consequence of one or many of the channels. The hydrogen explosion destroyed the upper part of the reactor. The central reason has been: Burning of large amounts of zirconium by steam at elevated temperatures and hydrogen production. Here it has to be mentioned that this reaction is strong, self-sustaining because it produces large amounts of heat. As a final consequence, there has been fuel melting in the channels.

As I mentioned before, the reactor consists of 1,700 channels like independent small reactors. Additionally to the physics control, these small reactors made by one channel must be controlled by engineering safeguards for thermodynamic reasons. So far as we know, this is very difficult and the probability of malfunction of this system is rather high.

The reaction of graphite with steam or air is much slower. The reaction of zirconium with steam is faster and in the first stage of this accident, graphite was a sink which has moderated the influence to delay of the reaction.

There are important differences to Western reactor types: The reactor did not have a containment for the core, and also not an emergency cooling system in the sense of our safety philosophy.

I should mention that in principle, the Magnox reactor types in Great Britain and in France are similar systems. Instead of combination of zirconium and seam, these reactors have a similar combination of magnesium and carbon dioxide. But in any case, the Magnox type reactors have much lower power density and is enclosed in a big concrete containment. For these reactors, there are good experience over 30 years.

The HTR working with low enrichment has also a graphite moderator. Core melting in this reactor type is excluded. In a case of loss of coolant, graphite is a rather large heat sink and the temperature in this system will increase in the case of a loss of cooling, by 600 to 700 C in average after a time of 8 to 10 hours.

At this time, the heat is transported by heat conductivity of the system to the outside, and the maximum temperature in a small part of the reactor will not be higher than 1,600 C. Many of our experiments show that under these conditions, there is not a release of radioactive material from the fuel elements.

The heating up of the reactor by the loss of cooling has been demonstrated several times in safety experiments in our power plant AVR in Julich. It is so rare that the reactor did not get damaged, and continued operation again without any repeat work and without any influence on the fuel elements. For this reason, even for the worse case, the small HTR does not need an emergency cooling system. The reactor is stabilizing itself without release of radioactive materials.

It is a completely passive, safe system.

Air ingress, which could corrode and burn the graphite, is excluded by vessels combined with a concrete containment, which can be constructed underground. The vessels and the vented containments have only small penetrations. Depressurization of the coolant helium is possible, but the contamination is so low that there is no harm to the environment.

In all cases, air ingress is negligible; for instance, in the THTR of 300 megawatts, the reactor has only holes with the diameter of 6 centimeters. In the worse case, this means during several weeks, a maximum corrosion of graphite less than 100 kilograms on the 100 tons of fuel elements—that means less than one per mil, and there is no release of radioactivity.

Experiments of air ingress have been made in large extent by mockups.

For all accidents, the influence to the environment is so small that evacuation of people is not necessary. This behavior of the HTR reactor is not dependent on human error.

In addition to the development work of the United States and in Germany, there is going on development work parallel in the Soviet Union, in the Kurchatov-Institute and other institutes.

For my last visit to the Kurchatov-Institute, I know that the staff consists of more than 1,000 scientists and engineers working on the pebble bed concept, similar to the German design. There may be a feasibility to get agreement, that an agreement can be established with the East Block countries for the application of passive, safe reactor systems.

Senator **Domenici** [presiding]. Dr. Schulten, would you mind just letting me ask you a question, please. We have a very serious time problem, and we had asked witnesses——

Dr. **Schulten**. A half-minute—just in 1 minute.

Senator **Domenici**. That is fine. I was going to ask you what you thought it would take.

Dr. **Schulten**. The bigger market of nuclear energy in the next decades are the small reactors. This is demonstrated by studies of international organizations. The most people in the world are living in regions with small networks of transportation lines so that only small units can be used.

Also, the heat application for cogeneration of nuclear steam and oil recovery need only small units. Therefore, I guess in the next decade, a large number of passive, safe reactors are necessary, especially for countries that have not the technology to make active, safe systems which are used in the reactors today.

Thank you, very much.

Senator **Domenici**. Thank you, very much, Doctor. We greatly appreciate the time and effort that you have taken to come and share your information with us.

[The prepared statement of Dr. Schulten follows:]

# STATEMENT SUBMITTED FOR THE RECORD

SENATE ENERGY AND NATURAL RESOURCES COMMITTEE

UNITED STATES SENATE

# THE CHERNOBYL ACCIDENT

# AND

# IMPLICATIONS FOR THE DOMESTIC NUCLEAR INDUSTRY

JUNE 19, 1986
PROFESSOR DR. RUDOLF SCHULTEN
NUCLEAR RESEARCH CENTER
JULICH, GERMANY

Prof. Dr. Rudolf Schulten
Nuclear Research Centre Jülich

May I introduce myself. My name is Schulten. I work in the Nuclear Research Centre Jülich which is located near Cologne in Germany and which is one of the two big nuclear centers in my country. I am working there as the leader of the HTR Development since more than 20 years. At the same time in the last years, I am also the Vice President of the technical University in Aachen. I was in charge of the construction of the AVR, the first High Temperature reactor in Germany, and I was also the project leader for the planning and development of the second High Temperature Reactor - the THTR, a plant of 300 MW(e).

The German HTR-Program now is going on since more than 20 years. The main goal of the development is: "Reactors with passive safety".

Since about 20 years we have the AVR reactor with 15 MW(e) and 950 °C in operation quite successfully. Since several months the THTR has been in startup operations.

In the 20 years development program a large number of experiments have been made. The most important are fuel element tests, safety experiments, tests for corrosion, earthquakes, and concrete vessels. A large number of physical calculations and safety analysis of this reactor type have been made. The safety analysis have been proved and agreed by licensing authorities. Also, a lot of experiments and studies have been made for the application of nuclear

PROCESS HEAT FOR THE CHEMICAL INDUSTRY, OIL RECOVERY, AND COAL REFINERY, UP TO NOW ABOUT 5 BILLION DEUTSCH MARKS, INCLUDING THE CONSTRUCTION OF REACTORS, HAVE BEEN SPENT IN OUR COUNTRY. TWO SUPPLIER COMPANIES ARE BIDDING FOR SMALL HTR REACTORS, AND A 500 MW(E) PLANT IS IN THE PLANNING STAGE.

NOW TO THE ACCIDENT AT CHERNOBYL. IT IS A BOILING WATER REACTOR WITH A BIG QUANTITY OF ZIRCONIUM OF MORE THAN 100 TONS AND IS MODERATED BY GRAPHITE. 1700 VERTICAL CHANNELS ARE IN THE REACTOR. THIS IS A SYSTEM OF A LARGE NUMBER OF ALMOST INDEPENDENT ELEMENTS WHICH MUST BE CONTROLLED EACH BY ENGINEERING SAFEGUARDS. THE FACTS WHICH WE KNOW ARE NOT CLEAR ENOUGH TO SAY THE EXACT REASONS FOR THE ACCIDENT. BUT IT IS SURE THAT THE ACCIDENT STARTED WITH A CHEMICAL EXPLOSION OF HYDROGEN WHICH WAS CREATED BY THE VERY FAST REACTION OF ZIRCONIUM WITH STEAM. OUR OWN PHYSICAL CALCULATIONS OF THE NUCLEAR CORE SHOW IN AGREEMENT WITH DATA FROM THE LITERATURE THAT THE CORE IS RATHER INSTABLE, BECAUSE THE REACTIVITY AND POWER INCREASES WHEN WATER IS LOST AND WHEN THE TEMPERATURE OF THE MODERATOR IS GOING UP. THE SO-CALLED XENON OSCILLATIONS DEPENDING FROM POWER AND TEMPERATURE DISTRIBUTION MAKE THE CONTROLLING OF THIS REACTOR EVEN MORE COMPLICATED. THEREFORE IT IS NOT SURPRISING THAT THERE HAS HAPPEND A NUCLEAR EXCURSION.

THE ZIRCONIUM-STEAM REACTION WAS A CONSEQUENCE OF A DRYOUT OF ONE OR MANY OF THE CHANNELS. THE HYDROGEN EXPLOSION DESTROYED THE UPPER PART OF THE REACTOR. THE CENTRAL REASON HAS BEEN: BURNING OF LARGE AMOUNTS OF ZIRCONIUM BY STEAM AT ELEVATED TEMPERATURE AND HYDROGEN PRODUCTION. HERE IT HAS TO BE MENTIONED THAT THIS REACTION IS STRONG SELFSUSTAINING BECAUSE IT PRODUCES LARGE AMOUNTS OF HEAT. AS A FINAL CONSEQUENCE THERE HAS BEEN FUEL MELTING IN THE CHANNELS.

AS I MENTIONED BEFORE, THE REACTOR CONSISTS OF 1700 CHANNELS LIKE INDEPENDENT SMALL REACTORS. ADDITIONALLY TO THE PHYSICS CONTROL THESE SMALL REACTORS MADE BY ONE CHANNEL MUST BE CONTROLLED BY ENGINEERING SAFEGUARDS FOR THERMODYNAMIC REASONS. SO FAR AS WE KNOW, THIS IS VERY DIFFICULT AND THE PROBABILITY OF MALFUNCTION OF THIS SYSTEM IS RATHER HIGH.

THE REACTION OF GRAPHITE WITH STEAM OR AIR IS MUCH SLOWER. THE REACTION OF ZIRCONIUM WITH STEAM IS FASTER AND IN THE FIRST STATE OF THIS ACCIDENT, GRAPHITE WAS A HEAT SINK WHICH HAS A MODERATING INFLUENCE TO DELAY THE REACTION. THERE ARE IMPORTANT DIFFERENCES TO WESTERN REACTOR TYPES: THE REACTOR DID NOT HAVE A CONTAINMENT FOR THE CORE AND ALSO NOT AN EMERGENCY COOLING SYSTEM IN THE SENCE OF OUR SAFETY PHILOSOPHY.

I SHOULD MENTION THAT IN PRINCIPLE THE MAGNOX REACTOR TYPES IN GREAT BRITAIN AND IN FRANCE ARE SIMILAR SYSTEMS. INSTEAD OF A COMBINATION OF ZIRCONIUM AND STEAM, THESE REACTORS HAVE A SIMILAR COMBINATION OF MAGNESIUM AND CARBON DIOXIDE. BUT IN ANY CASE, THE MAGNOX TYPE REACTORS HAVE A MUCH LOWER POWER DENSITY AND IS ENCLOSED IN A BIG CONCRETE CONTAINMENT. FOR THESE REACTORS THERE ARE GOOD EXPERIENCE OVER 30 YEARS.

THE HTR WORKING WITH LOW ENRICHMENT HAS ALSO A GRAPHITE MODERATOR. CORE MELTING IN THIS REACTOR TYPE IS EXCLUDED. IN A CASE OF LOSS OF COOLANT, GRAPHITE IS A RATHER LARGE HEAT SINK AND THE TEMPERATURE IN THIS SYSTEM WILL INCREASE IN THE CASE OF A LOSS OF COOLING BY 600 TO 700 °C IN AVERAGE AFTER 8 TO 10 HOURS. AT THIS TIME

THE HEAT IS TRANSPORTED BY HEAT CONDUCTIVITY OF THE SYSTEM TO THE OUTSIDE, AND THE MAXIMUM TEMPERATURE IN A SMALL PART OF THE REACTOR WILL NOT BE HIGHER THAN 1600 °C. MANY OF OUR EXPERIMENTS SHOW THAT UNDER THESE CONDITIONS THERE IS NOT A RELEASE OF RADIOACTIVE MATERIAL FROM THE FUEL ELEMENTS. THIS HEATING UP OF THE REACTOR BY THE LOSS OF COOLING HAS BEEN DEMONSTRATED SEVERAL TIMES IN SAFETY EXPERIMENTS IN OUR POWER PLANT AVR IN JÜLICH. THE RESULTS WERE THAT THE REACTOR DID NOT GET DAMAGED AND CONTINUED OPERATION AGAIN WITHOUT ANY REPAIR WORK AND WITHOUT ANY INFLUENCE ON THE FUEL ELEMENTS. FOR THIS REASON EVEN FOR THE WORST CASE THE SMALL HTR DOES NOT NEED AN EMERGENCY COOLING SYSTEM. THE REACTOR IS STABILIZING ITSELF WITHOUT RELEASE OF RADIOACTIVE MATERIALS. IT IS A COMPLETELY PASSIVE, SAFE SYSTEM.

AIR INGRESS WHICH COULD CORRODE AND BURN THE GRAPHITE IS EXCLUDED BY VESSELS COMBINED WITH A CONCRETE CONTAINMENT, WHICH CAN BE CONSTRUCTED UNDERGROUND. THE VESSELS AND THE VENTED CONTAINMENTS HAVE ONLY SMALL PENETRATIONS. DEPRESSURIZIATION OF THE COOLANT HELIUM IS POSSIBLE, BUT THE CONTAINMENT IS SO LOW THAT THERE IS NO HARM TO THE ENVIRONMENT. IN ALL CASES AIR INGRESS IS NEGLIGIBLE, FOR INSTANCE, THE THTR HAS ONLY HOLES WITH THE DIAMETER OF 6 CENTIMETERS. IN THE WORST CASE, THIS MEANS DURING SEVERAL WEEKS A MAXIMUM CORROSION OF GRAPHITE LESS THAN 100 KILOGRAMS ON THE 100 TONS OF FUEL ELEMENTS, AND THERE IS NO RELEASE OF RADIOACTIVITY. EXPERIMENTS OF THIS AIR INGRESS HAVE BEEN MADE IN LARGE EXTENT BY MOCK-UPS.

FOR ALL ACCIDENTS THE INFLUENCE TO THE ENVIRONMENT IS SO SMALL THAT EVACUATION OF PEOPLE IS NOT NECESSARY. THIS BEHAVIOUR OF THE HTR REACTOR IS NOT DEPENDENT ON HUMAN ERROR.

IN ADDITION TO THE DEVELOPMENT WORK IN THE US AND IN GERMANY THERE IS GOING ON DEVELOPMENT WORK IN THE SOWJET-UNION IN THE KURCHATOV-INSTITUTE AND OTHER INSTITUTES. FROM MY VISITS TO THE KURCHATOV-INSTITUTE I KNOW THAT THE STAFF CONSISTS OF MORE THAN 1000 SCIENTISTS AND ENGINEERS WORKING ON THE PEBBLE BED CONCEPT, SIMILAR TO THE GERMAN DESIGN. THEREFORE IT IS FEASIBLE THAT AN AGREEMENT CAN BE ESTABLISHED WITH THE EAST BLOC COUNTRIES FOR THE APPLICATION OF PASSIVE, SAFE REACTOR SYSTEMS.

THE BIGGER MARKET OF NUCLEAR ENERGY IN THE NEXT DECADES ARE THE SMALL REACTORS. THIS IS DEMONSTRATED BY STUDIES OF INTERNATIONAL ORGANIZATIONS. THE MOST PEOPLE IN THE WORLD ARE LIVING IN REGIONS WITH SMALL NETWORKS OF TRANSPORTATION LINES, SO THAT ONLY SMALL UNITS CAN BE USED. ALSO, THE HEAT APPLICATION FOR COGENERATION AND NUCLEAR STEAM FOR OIL RECOVERY NEED ONLY SMALL UNITS. THEREFORE, I GUESS IN THE NEXT DECADES A LARGE NUMBER OF PASSIVE, SAFE REACTORS ARE NECESSARY.

## CONCLUSIONS:

THE HTR IS CHARACTERISED BY THE FOLLOWING ITEMS:

1) IT HAS A PASSIVE, SAFETY SYSTEM.
2) HUMAN ERRORS ARE NOT DANGEROUS
3) EVACUATION OF PEOPLE IN THE WORST CASE IS NOT NECESSARY.

THIS MEANS A NEW ERA OF REACTOR SAFETY PHILOSOPHY.

Senator DOMENICI. Mr. Taylor, we will be delighted to hear your testimony.

## STATEMENT OF JOHN J. TAYLOR, VICE PRESIDENT, NUCLEAR POWER, ELECTRIC POWER RESEARCH INSTITUTE

Mr. TAYLOR. Thank you, Senator. I have submitted my statement and I am going to simply make the major points that are covered there, and address a couple of other questions that were raised at the first panel discussion.

The primary objective of the EPRI Nuclear Power Program is to provide technology to improve the safety and reliability of the nuclear powerplants. In keeping with that objective, EPRI continues to review and study the many aspects of safety in the U.S. nuclear powerplants.

After the accident at TMI, EPRI took a series of initiatives following the accident, to further our understanding of this accident and strengthen utility systems to assure the safety of nuclear power.

The Nuclear Safety Analysis Center was formed to do indepth reviews of the accident, to pinpoint the causes, to find corrective actions. Also, on a continuing basis, to examine carefully incidents in the field, identify accident precursors, and communicate them to the United States.

More recently, INPO has taken on the daily task of doing that, using systems set up at the time.

An important issue was to launch a major research program to better understand severe accidents and the potential for release of radioactivity to the atmosphere. That work had a heavy element of developing methodology for probabilistic risk assessment, and the comments made earlier today about the 45-percent change of an accident, a severe accident in this country, I would like to dwell on for a moment in light of our experience.

That evaluation was done for a subset of plants and represents in fact a somewhat higher estimate of probability than we have seen from some more recent estimates for plants. To multiply that number by the entire number of plants in the United States, I think is an error in the first place, giving a very much higher estimate of the probability of difficulty.

Further, for the most part, those evaluations were made to identify the occurrence of the beginning of trouble; the onset of loss of core cooling. Our experience at TMI-2 and many other evaluations have shown when you reach that point, there are many other events, signals that occur which would provide some substantial time for operator action.

So the probability of moving from the onset of core cooling to a severely damaged core is substantially lower.

Furthermore, even if that happens, the source term work we have done indicates that containment does perform its function to protect the public from further dissemination of fission products.

So the picture that one is faced with serious public risk, with one chance in two, in the rest of this century, in my opinion, is an alarmist statement.

One other feature which is extremely important in these evaluations is operator action. For the most part these methods assumes the operator does not take effective action in responding to the emergency condition.

We know that is in effect in doing these risk assessments and have launched a program which now is being done cooperatively with the major national utility in France, to measure the response time of operators under full-scale simulation of accident condition. We are not finished with that, but what we have so far is an indication that if we apply the data, we will find that the probabilities of getting into a truly severe core melt condition are 10 times lower than our present methods would indicate.

I would like now to discuss—my paper points out the many other areas of work we have undertaken and reliability, particularly to address the lessons from TMI-2, and I will not repeat those.

Many of these actions that we took were done at the request of the Utility Nuclear Power Oversight Committee of the utility. A steering group of chief executive officers of the nuclear utility.

Shortly after Chernobyl, this group supported an industry technical review group, functioning with AIF staff support, to evaluate the causes, postaccident response, and recovery experience of the Chernobyl accident, identify whatever lessons there may be for U.S. commercial nuclear powerplants and responding to the legitimate questions raised by the accident.

That group met on May 29, and finalized the industry efforts on Chernobyl, and EPRI has been asked by UNPOC to provide technical support for that evaluation. So our staff has been working to understand the events of Chernobyl and to develop an understanding of what lessons from that event can be applied to our U.S. commercial nuclear power industry.

A thorough understanding of the sequence of events and a thorough understanding of the performance of all the safety systems and operator actions during the event is crucial to developing sound conclusions and recommendations.

We are concerned that pressures on the NRC and on our industry to produce quick answers and quick fixes in response to Chernobyl may preclude doing the thorough job of analysis that is so important to rational decision-making. We must avoid the temptation to shoot from the hip.

I would like to make a comment on some discussions earlier today which I believe are of the nature of shooting from the hip.

EPA was challenged on why it did not consider seriously a report of a measurement in Europe of 1.5 millirem per hour, or 1,500 roentgens; 1,500 roentgens will kill a person in 1 to 2 hours, so on the very face of it that information is inappropriate.

There is also great discussion of the possibility of several hundred thousand people getting cancer as a result of the Chernobyl accident. Now, I agree with the statement made by EPA that they do not want to make guesses without the information on what the exposure of those people would be.

But we do have information from the tragedy of the bombings in Japan. There were 285,000 survivors of that bombing, which as you well know killed tens of thousands of people, who had excess radiation dose.

Of that, over the many, many years, because of the sincere support and interest of the United States and this Congress, the Commission was set up to study the health of those people for the rest of their lives.

At this juncture, 30-plus years later, 70,000 people have died; 14,000 of those from cancer and 415 of those cancers have been concluded have come from the excess radiation exposure.

I find it very hard to accept the comments of 300,000 cancer deaths in the Chernobyl accident, where tens of people—not tens of thousands of people—were killed.

We would love to know enough about exposure so we could make our estimates and respond to legitimate questions which the Senator has raised. I agree totally with his remark; we must know. We must understand those issues and we would like to see the Soviet Union, perhaps in combination with the World Health Organization, do the same thing the United States did with the Japan survivors; study their health through the rest of their lives, and develop a base through which we can understand better the consequences of excess radiation exposure.

Senator DOMENICI. Mr. Taylor, let me ask you—I don't intend to inquire of each witness, but you mentioned the cancer deaths as a result of the bomb. Then you said there is a small number that are directly related to—provable as related to the excess radioactivity to which they were exposed.

Is the remaining number of cancer deaths an inordinately high number of cancer deaths?

Mr. TAYLOR. No. That is on a statistical basis what one would expect from that population not associated with overexposure of radiation.

Senator DOMENICI. All right.

Mr. TAYLOR. Incidentally, without that carefully study, it would have been near impossible to even recognize the difference; to be able to single 400 out of the 14,000 is a difficult task.

Well, to get on then, following our time work, there were long lists of new requirements and an attempt to require that everything be done at once. In retrospect, many of the new requirements were excellent but the effort to implement them without prioritization led to unforeseen complications.

We believe the industry and NRC both learned much from that experience and as a minimum, we believe it would be premature to make proposals for additional changes to U.S. approaches to safety prior to receiving and analyzing the full report on the accident from the Soviet Union.

The content of this paper then gets into the discussion of the differences between these systems, and I don't intend to repeat what has been said by many capable people on the panel, and hope perhaps that the record itself will provide some amplification.

The emphasis on the differences is not intended to suggest that there are no lessons from Chernobyl, but to help us focus on the facts and to ensure that correct lessons are identified.

One comment, we have divided the differences into reactor design differences, which have been discussed; containment differences, which have been discussed; and safety system differences which have been discussed.

In just a summary statement on safety system differences: We concluded that the Soviet designs don't address the full scope of design basis accidents that we do in the United States, nor do they treat low probability, high consequent scenarios, accident mitigation, and emergency response in the detail that we have had, particularly, since TMI.

Many of the accidents they do consider, such as individual channel blockage, are unique to their designs, and many of the accidents they don't appear to consider are within the U.S. design basis.

Finally, we think that U.S. technical specifications for reactor operation, limiting conditions of operation, emergency procedures, realistic operator training and many other operations related features that are important to reactor safety in the United States may not each receive the same level of attention in the Soviet Union.

In summary, I think the United States might well be proud, in retrospect of the Chernobyl accident, and particularly, the Congress, for two fundamental policy decisions at the outset of the program. When the first shippingport plant it was decided to put containment on it. For the next 30 years, we have been honing, improving, evaluating the capability of containment and the consequences of potential release of radiation.

This has been backed up by a massive safety research and development program, through your generosity, so we are literally decades ahead of the Soviet Union because a policy was established quite distinct from theirs which chose not to have containment.

Those of us who implement policies are subject to a substantial amount of error, difficulty in being perfect in implementing it. But you should be proud that you set the right policy, which makes it a heck of a lot easier for us.

The second one, you separated civilian nuclear power development from weapons production, and the Soviet channel reactor is a dual purpose reactor. They chose not to separate it.

As an engineer, I am glad I was not given the job designing an optimum power producer in the same machine as an optimum plutonium producer. That is what they have tried to do.

I think the industry, too, can be proud of its overall record of improvement since the TMI accident. I think Zack Pate is going to give you some very specific data on those improvements.

Safety has been improved as a result of both regulatory effort and the industry initiatives. If we give appropriate credit to the improvements of the last 7 years, as we intensify our efforts to make these more uniformly excellent throughout our industry and search through the lessons of Chernobyl for opportunities for further improvement, we probably will find that the important lessons of reactor safety have been learned already and applied in the United States.

We look forward to a new level of international cooperation on reactor safety and will continue to work with Government and industry organizations to ensure safety in the design, construction, and operation of nuclear powerplants.

Thank you, Senator.

[The prepared statement of Mr. Taylor follows:]

# Statement to

# Senate Committee on Energy and Natural Resources
of the
United States Senate

John J. Taylor
Vice President, Nuclear Power
Electric Power Research Institute

June 19, 1986

# Statement of John J. Taylor

Before the Senate Committee on Energy and Natural Resources

June 19, 1986

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I am John Taylor, Vice President, Nuclear Power, Electric Power Research Institute (EPRI). I want to thank the Chairman and the other members of this Committee for the opportunity to express our views on this very important subject.

A primary objective of the EPRI nuclear power program is to provide technology to improve the safety and reliability of nuclear power plants. In keeping with that objective, EPRI continues to review and study the many aspects of safety in U.S. nuclear power plants. After the accident at TMI, EPRI took a series of initiatives following the TMI-2 accident to further our understanding of nuclear accidents and strengthen utility systems for assuring the safety of nuclear power:

(1) The Nuclear Safety Analysis Center (NSAC) was formed, and an in-depth review of the TMI-2 accident was carried out to pinpoint the causes, define corrective actions, and publish a detailed analysis of the accident.

(2) NSAC was assigned to evaluate operating reactor incidents so as to identify generic accident precursors and root causes and communicate them to all U.S. nuclear utilities. The SEE-IN (the evaluation phase) and NETWORK (the communication phase) systems, initially developed by NSAC, have now been turned over to INPO and

have become vital and continuing processes in the industry.

(3) A major research program was launched to better understand severe accidents and the potential for release of radioactive materials to the atmosphere (the "source term").

(4) The entire EPRI nuclear power R&D program in safety and reliability was re-oriented on the basis of the "lessons learned" from TMI-2 and the recommendations of the Kemeny Commission and other investigations of the TMI-2 accident. A major safety relief valve test program was implemented. Improved devices for valve position indication were developed. A large-scale hydrogen control test program was implemented. Major attention was given to improvement of human factors in operation and maintenance, including diagnostic aids and system-oriented procedures for improved emergency response, signal validation techniques, and simulator qualification standards. Development and application of probabilistic risk assessment methodology was intensified, particularly in the treatment of human error inputs and common mode failure. Extensive testing of emergency core cooling systems and small break loss of coolant accident transients was implemented. Major effort was devoted to develop improved in-service inspection techniques and to establish inspector training qualification programs. Time does not permit a full summary of these activities.

Many of the actions taken by EPRI after the Three Mile Island accident were undertaken at the request of the Utility Nuclear Power Oversight Committee (UNPOC), a steering group of chief executive officers of nuclear utilities. Shortly after Chernobyl, UNPOC supported an industry technical review group, endorsed by the AIF Board, to evaluate the causes, post-accident response, and recovery experience of the Chernobyl accident, identify whatever lessons there may be for U.S. commercial nuclear power plants, and respond to the legitimate questions raised by the accident. That group met on May 29th and formalized the industry efforts on Chernobyl. EPRI has been asked by UNPOC to provide technical support for these industry efforts.

Our staff has been working to understand the events of the Chernobyl accident and to develop an understanding of what lessons from that event can be applied to our U.S. commercial nuclear power industry. We have found, as others have, that detailed technical information on Soviet plant designs and operation is difficult to obtain. We have also found that the lack of detailed accident information at this time has made it virtually impossible to develop a thorough analysis of the event, as we did for the Three Mile Island accident. EPRI has responsibility to the electric utilities to do what we can to develop the best possible technical explanation of the accident and its consequences. Industry groups such as EPRI, INPO, and AIF are working together with NRC, DOE, the IAEA, and hopefully with the Soviets, to obtain adequate information to create a detailed sequence of events and thorough understanding of root causes and consequences of the Chernobyl accident.

One of the most important lessons we learned from our Nuclear Safety Analysis Center analyses of the Three Mile Island accident, and other significant events which NSAC analyzed and reported, is that a thorough understanding of the sequence of events and a thorough understanding of the performance of all the safety system and operator actions during the event, is crucial to developing sound conclusions and recommendations. We are concerned that pressures on the

NRC and our industry to produce quick answers and quick fixes in response to the Chernobyl accident may preclude doing the thorough job of analysis that is so important to rational decision making. We must avoid the temptation to 'shoot from the hip.' Following TMI, there were long lists of new requirements, and an attempt to require that everything be done at once. In retrospect, many of the new requirements were excellent, but the effort to implement them without prioritization led to unforeseen complications. We believe the industry and the NRC both learned much from that experience. As a minimum, we believe it would be premature to make proposals for additional changes to U.S. approaches to safety prior to receiving and analyzing the full report on the accident from the Soviet Union.

One of the major reasons which mandates that we analyze this event carefully prior to formulating recommendations for U.S. light water reactors (LWRs) is that the Soviet designs are significantly different from ours. Fundamental design and operational differences exist that make side-by-side comparisons extremely difficult. These fundamental differences lead us to draw two immediate conclusions:

1. First, the differences will make it difficult to draw easy applications to the U.S. situation. Many of the lessons from Chernobyl will not apply to U.S. plants. Some lessons will apply, and must be analyzed. Initial challenges or event initiators can be very similar between U.S. and Soviet plants. Also, we believe the consequences of the Chernobyl accident, in terms of accident source terms, radioactive transport, health effects, and cleanup efforts are all important areas that U.S. scientists must study and apply as appropriate to our own safety programs and analysis efforts.

2. Second, we must not fail to recognize the most obvious fact about U.S.-Soviet nuclear power program comparisons: Chernobyl was vastly different from our 1979 accident at Three Mile Island. Despite the fact that each experienced major core damage, the public health effects from the Three Mile Island accident and the Chernobyl accident are dramatically different. No deaths or radiation injuries resulted from the Three Mile Island accident. The exhaustive Pennsylvania Department of Health study completed last September found no evidence of increased cancer among area residents due to the 1979 accident at TMI. No damage to crops or livestock occurred, and no cleanup of land outside the plant boundaries was required. Our basic design and safety philosophy - namely, defense in-depth with multiple safety barriers - and the implementation of this approach in the U.S. designs and operations account for that difference. The analysis of Chernobyl will no doubt reveal some opportunities for further improvements in the design and operation of U.S. reactors, but we must not lose sight of the fact that TMI-Chernobyl comparisons indicate that our program is fundamentally sound. This is a credit not only to our industry, but to the NRC and to the Congress, all of whose efforts have been open to public scrutiny within our democratic process. They all have worked together to achieve high standards of safety.

I would like to take a few minutes to explain in more detail some of these important differences between U.S. and Soviet reactor designs. I must again emphasize that our information on Soviet designs is incomplete. My emphasis on the following differences is not intended to suggest that there are no lessons to learn from Chernobyl, but to help us focus on the facts and to ensure that correct lessons are identified. My summary of fundamental design differences will be divided into three areas: reactor differences, containment differences, and safety system differences. My point of comparison will be the U.S. light water reactor.

## REACTOR DIFFERENCES

The Chernobyl reactors are light-water cooled, graphite moderated, vertical pressure tube, boiling water reactors. These 1000 MWe plants are called "RBMK-1000's" by the Soviets. The RBMK reactors are the dominant standard Soviet design. RBMK-type designs comprise over one-half of all operating Soviet power reactors and about 65% of their nuclear capacity.

The first difference between Soviet RBMKs and U.S. LWRs is the use of graphite as a neutron moderator. The RBMK design evolved in the Soviet program from earlier weapons production reactors that used graphite and low enrichment uranium. U.S. designers selected the light water coolant as moderator over graphite for power reactor applications for a number of reasons:

- First, the concerns associated with a potentially flammable material inside the reactor core are avoided, along with all the complex support systems that go with it (moderator heat removal, cover gas, fire protection, etc.).

- Second, the unique physical problems of graphite under irradiation, requiring annealing of the Wigner energy effects, are avoided.

- Third, the Soviet graphite reactors are very large in physical size. We have had favorable experience with the more compact LWR systems.

- Fourth, they are very complex when compared to U.S. LWRs. About 1700 individual pressure tubes are embedded in the 1800 tons of graphite, each with its individual inlet and outlet piping.

- Fifth, the advantages of graphite moderation in a water-cooled reactor are associated with production of material for weapons: use of very low enrichment or natural uranium and on-line refueling. Co-production of commercial power and weapons materials was not supported by our government or scientific experts; and graphite moderation was not attractive to U.S. utilities, who had no interest in providing materials for the U.S. weapons program.

My discussion of the significant differences between graphite and water moderation is not meant to say that graphite is dangerous inherently. The U.S. technical community has made important improvements in graphite safety, and defense-in-depth can be designed into graphite reactors.

The next major difference between U.S. and Soviet reactor designs is in the defense-in-depth barriers. These are provided to ensure that nuclear fuel and fission products cannot escape the core. Both Soviet RBMK reactors and U.S. LWRs use $UO_2$ fuel pellets surrounded by a zirconium cladding or 'can' of about 0.02 inches to 0.03 inches wall thickness. These fuel elements are similar, but the next barrier of defense against release is radically different. The Soviets use about 1700 individual zirconium alloy pressure tubes, 23 feet high, and 3 1/2 inches in diameter to contain the fuel elements and light water coolant flowing past the fuel elements. The pressure tube walls are about 0.16 inches thick and are located within 1/4 inch of the fuel cladding; whereas the pressure vessel walls on U.S. LWRs are about 6 1/2 to 8 1/2 inches thick, and are separated from fuel and fuel cladding by about two feet of water and steel thermal shielding. This means that during an accident, overheated and damaged fuel elements on a Soviet RBMK reactor have a much greater chance of penetrating this second barrier of defense (the pressure tubes) than on a U.S. LWR (a single large pressure vessel).

These first two Soviet differences, use of graphite as the moderator and thin-walled pressure tubes, combine to form a third distinction, the possibility of creating dangerously hot-graphite/hot-steam reactions from a breach in the pressure tube wall. This reaction releases carbon monoxide and hydrogen gas, which can burn or explode in the presence of oxygen.

As at TMI, when the core overheated, hydrogen was generated from the chemical reaction between the hot zircalloy cladding and the water or steam. However, two important differences between U.S. and Soviet RBMK reactor designs impacted the consequences of hydrogen production from zirconium-water reactions. First, the Soviet design includes two to seven times more zirconium inventory than U.S. LWRs, and thus the potential for much more hydrogen production. Second, the likelihood that oxygen can come in contact with this chemically produced hydrogen in an accident is much greater in the Soviet RBMK design. At the time of the TMI accident, there was never any danger from explosion of the hydrogen bubble in the pressure vessel. Oxygen gas was not present in the reactor coolant system, so no explosion was possible.

Although both the RBMK and LWR designs use light water as coolant, the different reactor designs create some unique cooling and stability problems for the Soviets. First, with a relatively small water inventory in the reactors, little time is available to respond to challenges such as losses of inventory, before coolant boiloff and fuel overheating begins. Individual fuel channels may boil dry if there are channel-to-channel instabilities between pressure tubes.

Even more important, loss of coolant does not appear to result in the fail-safe negative reactivity that exists in U.S. designs. Soviet reactors have exhibited positive steam void reactivity coefficients which required design changes including control rod changes, increased reactor control computerization, and increases in fuel enrichment. By contrast, both the UK and Canada carefully considered pressure tube designs with reactivity coefficients similar to the RBMK type design as an alternative for power reactors, and this inherent instability problem was stated as a key reason for rejecting this boiling water, vertical pressure tube design.

CONTAINMENT DIFFERENCES

I have summarized the major differences in Soviet RBMK vs. U.S. LWR reactor designs, and will now say a few words about reactor containment. The subject of Soviet containments has generated a great deal of discussion. On this subject, we find that technical information on RBMK containment capability is much less available than technical information on RBMK reactor designs. We believe this to be a result of relatively slow development of containment technology in the Soviet program. Early Soviet reactors had no containment whatsoever. Incremental steps have been taken on subsequent generations of RBMK designs to improve on this situation, but to this date we are unaware of any operating or under-construction Soviet RBMK with a full primary containment in the sense we in the West define full containment

To us, full containment means complete enclosure of all reactor and primary support systems for the reactor such that any design basis accident is contained inside. Full primary containment is achieved typically in the U.S. by building a strong, thick steel and concrete containment vessel around all primary reactor systems. The containment is either large enough to contain the peak pressure anticipated for the worst design basis accidents, or has sufficient "pressure suppression" or steam condensing capacity to contain that worst case peak pressure. Most U.S. LWRs have containments with design pressures of about 60 psi with ultimate yield strengths as high as 3 times that figure. For some U.S. containments with lower design pressures, such as BWR MK-3 and ice condensers, sufficient pressure suppression capacity is installed to limit the worst case accident peak pressure to a much lower value that is well within the containment design. Needless to say, the capability of a containment to perform its design purpose successfully is not merely a function of its design pressure, but also its size and pressure suppression capacity. Finally, "full containment" as defined by the U.S. implies the ability to isolate completely and rapidly all containment penetrations, such as main steam and main feedwater piping under accident conditions.

We have heard of reports based on Soviet technical literature that credit the Chernobyl Unit 4 with containment. We have studied the Soviet literature and believe such claims probably are not correct in the sense that we define "full containment." This lack of containment seems to be substantiated by a recent Associated Press report that Ivan Emel'yanov, Deputy Director of the RBMK design organization, "confirmed speculation that the reactor did not have a conventional containment vessel used in the West to prevent radiation leaks in case of a breakdown." The evidence does appear to point toward newer RBMKs like Chernobyl-4 being equipped with some compartmentalization and a pressure suppression system called a 'bubbler pond'. Earlier RBMKs appear to have no such pressure suppression capability. But, as previously stated, even the more modern Soviet RBMK structural designs would not qualify in the U.S. as "containment." A more appropriate term would be "limited pressure suppression capability."

We base this conclusion of lack of full containment on four observations:

- First, it appears that only part of the primary system is enclosed within a boundary intended to be pressure tight. Reactor inlet piping is enclosed, but Soviet literature implies that reactor outlet piping and the four large steam drums or steam separators are outside the pressure suppression boundary enclosure. We doubt that the reactor core itself is protected by a strong pressure boundary. There is a sealed barrier around the core that encloses the mixture of helium and nitrogen that cools and protects the graphite from oxygen, but the pressure and explosion-handling capability of this region is doubtful.

- Second, the numerous piping penetrations of the various pressure boundaries and biological shields do not appear to be equipped with isolation capability (e.g., pressure tube exit isolation valves, main steam isolation valves, main feedwater isolation valves).

- Third, the design appears to be limited to the pressure suppression of certain specific break sizes and locations, and does not appear to envelope the full range of possible accident sequences for which U.S. containments are analyzed.

- Fourth, the structure does not appear to be designed to withstand burning or explosion of combustible gases from zirconium-water reactions or graphite-steam reactions. The inventory of potential chemical energy in the RBMK-1000 type reactor is very much greater than in an equivalent 1000 MWe light water reactor. As previously stated, the amount of zirconium is between two and seven times larger than comparable U.S. LWRs. Also, the RMBK's graphite combustion energy has no equivalent in light water reactors.

In general, Soviet compartmentalization appears directed at limiting the pressures from pipe breaks, not containing chemical energy or the activity that could be released in an accident. Again, the comparison of what happened at TMI and at Chernobyl helps explain the importance of these design differences. At TMI, very little activity escaped containment. Most of the small amount of activity that was released was in the form of gaseous fission products that present relatively small health risks in comparison to the particulate fission products that were contained effectively. As previously discussed, the hydrogen produced at TMI from the high temperature chemical reaction between zirconium and water did not result in combustion inside the reactor coolant system. However, some of the hydrogen did escape the reactor coolant system via a power operated relief valve and surge tank relief system. This hydrogen accumulation eventually resulted in a hydrogen burn and pressure buildup inside the TMI containment, but without any adverse consequences. The TMI containment building design was strong enough to contain overpressures from both escaping steam, and from hydrogen release and burn. In comparison, the Chernobyl accident appears to us to indicate a weakness in the Soviet RBMK design with respect to containing fission products and chemical energy.

## SAFETY SYSTEM DIFFERENCES

The final area of U.S. and Soviet designs that I wish to address is safety systems. This topic is perhaps the most difficult area of comparison, but also is an area that may yield the most useful applications to our industry. Soviet nuclear power plant safety criteria and systems will be difficult to analyze, not only because of the limited number of Soviet papers on the subject, but because we believe that the description of a safety system in Soviet literature does not necessarily mean the system described is in fact installed, tested, and available to perform its design function on each Soviet reactor. This makes it hard to do the kind of safety analysis and risk assessment that we do on U.S. LWRs. We understand that a Soviet design may call for three emergency diesels, where in fact the plant may operate before the third diesel is delivered to the site. We read a translation of a Soviet paper that describes the safety value of adding a turbine driven auxiliary feedwater pump. It may be describing a desired feature that is not yet installed, despite the implication that it is part of the design. It is our understanding that such a feature was not installed at Chernobyl. We also question whether tests and computer analyses of various modes of degraded heat transfer inside pressure tubes were part of the design process, or were conducted later to study the effects of accidents not considered originally, or to study the details and ramifications of flow and heat transfer instabilities observed during actual operations. I bring up the above points not as a criticism of Soviet safety systems, but as a caution against conclusions that can be drawn from Soviet literature that may later prove to be unwarranted extrapolation.

We have studied the available literature on RBMK safety systems. Soviet ECCS systems in modern RBMK designs appear to be similar to Western approaches, but appear to lack the degree of redundancy and diversity we have provided in our modern LWRs. For example, we believe that Soviet RBMKs may lack the capability for continuous injection of makeup water for post-scram decay heat removal in the event of a station blackout. This capability typically is provided on U.S. PWRs by a turbine driven Auxiliary Feedwater AFW Pump, and on U.S. BWRs by a turbine driven High Pressure Coolant Injection (HPCI) pump, or High Pressure Core Spray (HPCS) pump, as well as a smaller turbine driven Reactor Core Isolation Cooling (RCIC) pump.

We have concluded that Soviet designs do not address the full scope of design basis accidents that we do in the U.S., nor do they treat low probability, high consequence scenarios, accident mitigation and emergency response in the detail that we have since TMI. Many of the accidents they do consider, such as individual channel blockage, are unique to Soviet designs; and many of the accidents they don't appear to consider are within the U.S. design basis, such as earthquake and missiles. Finally, we think that U.S. technical specifications for reactor operation, limiting conditions of operation, emergency procedures, realistic operator training, and many other operations-related features that are important to reactor safety in the U.S. may not each receive the same level of attention in the Soviet Union.

## SUMMARY

The U.S. has reason to be proud of its overall record of improvement since the TMI accident. We have made major design, operational, and institutional improvements since TMI. Safety has been improved as a result of both regulatory actions and industry initiatives. If we give appropriate credit to the improvements of the last seven years as we intensify our efforts to make these more uniformly excellent throughout our industry and search through the lessons of Chernobyl for opportunities for further improvement, we probably will find that the important lessons of reactor safety have been learned already and applied in the U.S. We look forward to a new level of international cooperation on reactor safety, and will continue to work with government and industry oganizations to ensure safety in the design, construction and operation of nuclear power plants.

Senator **Domenici**. Thank you. Let me tell the panel, we do intend to listen and be here. What I must do for about 3 minutes is to temporarily adjourn. I have to return a long distance call. I will do that in this room, and return and then take the balance of the testimony.

So you are in recess for a few moments.

[Whereupon, a short recess was taken.]

Senator **Domenici**. Our next witness will be Zack Pate, president of the Institute of Nuclear Power Operations, Atlanta, GA.

## STATEMENT OF DR. ZACK T. PATE, PRESIDENT, INSTITUTE OF NUCLEAR POWER OPERATIONS

Dr. **Pate**. Senator, I appreciate the opportunity to discuss the Institute of Nuclear Power Operations and our work in promoting reactor safety.

The institute, or INPO, as we are usually called, was formed in 1979, in response to the Three Mile Island accident. We are a nonprofit corporation, incorporated in the State of Delaware. We are funded by the U.S. industry, plus 13 international participants. All 55 U.S. utilities that operate or are constructing nuclear plants are members of the institute.

As I indicated, we were created in response to Three Mile Island, but our work will be surely applicable to any lessons learned from Chernobyl.

INPO was established as an independent safety organization for the sole purpose of promoting excellence in the way nuclear plants in the United States are operated. We are not an advocate.

We are dependent on the industry, as a whole, but we have ample independence from any one member. We are also independent from the Government in the sense that none of our programs are funded by the Government.

Our key technical activities can be categorized into four cornerstone programs, and I will cover those very briefly; the evaluations of all the operating plants in the country, analysis of operating experience and feedback of the lessons learned to the industry, training and accreditation programs, and various forms of assistance, primarily aimed at sharing best practices among the utilities—something that simply was not done prior to Three Mile Island.

As just one example, we have conducted 227 evaluations at the operating plants since we were formed.

After Three Mile Island, the President appointed a commission to investigate the accident, the Kemeny Commission. I am pleased to report that all the Kemeny Commission recommendations that were under our jurisdiction have been implemented.

INPO's strength is in its people. We have 405 full-time professionals now. Dennis Wilkinson was the first president of INPO. Mr. Wilkinson was the first commanding officer of the Nation's first nuclear submarine, the U.S.S. *Nautilus* and later the first commanding officer of the U.S.S. *Long Beach,* the first nuclear powered surface ship.

Mr. Wilkinson retired as a vice admiral. At the time of his retirement, he headed the submarine warfare division for the Chief of Naval Operations. My background is not as distinguished, but not dissimilar. I had assignments as chief engineer and commanding officer of nuclear submarines. My last job in the Navy was working directly for Admiral Rickover, at his headquarters in Washington, and my responsibilities included overseeing the inspection program that Admiral Rickover ran, for ensuring safety in the nuclear powerplants in Navy ships.

In fact, all of my career, some 20 years in the Navy's nuclear propulsion program, focused on the safe operations of the plants, as did my work at graduate school at MIT, including a doctoral thesis on reactor safety.

Many other personnel at INPO have nuclear Navy experience. As you know, Admiral Rickover picked the best, and we have picked the best from among those. We have 71 people who were officers at one time or another in the Navy Nuclear Propulsion Program.

Shifting to experienced people from the commercial industry, we have 56 on our staff who have held certification as senior reactor operators in nuclear powerplants in the industry. That means that these people have hands-on control room experience and detailed knowledge of how the plant should be operated.

We have a total of 136 people with utility experience, and most of that is plant experience. The most senior member of that group is sitting right behind me, Mr. Bill Conway, who joined our staff just a few months ago. Mr. Conway was the plant manager at the Vermont Yankee Nuclear Power Station a few years ago, and was promoted through the successive positions to become the chief executive officer. He took early retirement from that position just a few months ago, and we are pleased to report that he has joined our staff.

We are seeing progress in many areas, but much of our work in the first 6 years has been in laying a foundation for excellence. To give you some examples, as mentioned briefly by Mr. Denton earlier, at the time of Three Mile Island, there were 10 full-scale, controlroom simulators in operation in the country. Today there are 52, and in a few more years there will be 75.

These simulators are as large as this end of the room we are in and cost $5 to $12 million. They are excellent training tools for the safe operations of plants.

Senator DOMENICI. What does the simulator contribute?

Dr. PATE. The simulator allows the operators to practice off normal and casualty, events that simply can't be practiced with the plant. They are very much like the simulators that the airlines now use to qualify their pilots.

Simulators are sophisticated enough that airlines can get their pilots certified without actually using the aircraft. You can take the simulator through off normal/and severe accident conditions which you can't do with the actual plant or the actual aircraft.

As a second example of putting the foundation in place, there were less than 1,000 full-time people dedicated to training in 1979. Today, there are just over 4,400, more than a fourfold increase. Similarly, floor space or office space dedicated to training was just under 500,000 square feet in 1979, and it exceeds 2 million square feet today, and there are 800,000 square feet under construction.

Soon we will have seen a fivefold increase in the amount of space that this industry has dedicated to the training of its people.

Early after its formation, INPO developed an accreditation program to help ensure that the 10 key functional positions in nuclear plants receive training that meets high standards. We formed an independent accrediting board of distinguished Americans to make an independent judgment as to whether those training programs deserve to be accredited.

To give you an idea of the scope of the work we were talking about, in 1984 and 1985, just over 12,000 people attended courses in the industry that are covered by the accreditation program.

In September of last year, we formed the National Academy for Nuclear Training to integrate these extensive training activities—the activities at each nuclear plant or at each training site, the activities of the accrediting board and the activities of the Institute of Nuclear Power Operations.

As of this month, our members report 453 training programs, and remember there are 10 at each station, so there are many throughout the country. But 453 training programs have been reported as ready for accreditation, and are awaiting a team visit by INPO personnel, and 193 of these programs have been accredited to date.

I could talk at length about accreditation and the National Academy, and I would be pleased to do so, but it is covered in my written testimony. I will shift now and talk about performance indicators, the measures of plant performance and the measures of progress that John Taylor of EPRI brought up a moment ago.

Let me first read a statement that has appeared in our annual report and many other places, and I think the statement is well accepted. "It is widely recognized that nuclear plants with high equivalent availability, small numbers of forced outages, few unplanned scrams, few significant events, low personnel radiation exposures are generally well managed overall. Such plants are more reliable and can be expected to have higher margins of safety."

It is that higher margin of safety that we are concentrating on. Over the past couple of years, we have developed a set of indicators that are shown in this folder, and I will show some examples in just a moment. A copy of the folder is provided in my testimony.

These indicators should tell us how individual plants are doing and how the industry is progressing overall.

You have 10 of these in the folders, but I will cover just 5.

Unplanned automatic scrams——We have seen a reduction in the average number per unit, 7.4 in 1980, to 4.3 in 1985. To save time, I will cover long-range goals as I go through the performance trends. We have worked with the industry to get every utility to set goals for 1990, to project, plan for and do the work that is necessary to achieve improved performance in each of these indicators, looking out 5 years to the future.

I must emphasize that these are goals set by the individual utilities, but the program is monitored by INPO. So where we have seen improvement in the first 5 years, the industry has set tough challenging goals for 1990.

Lost time accident rate is considered a good indicator of the attitude of the people at the plant and how much they respect the rules regarding safety. Lost time accident rate means accidents where someone cuts their hand, or breaks their leg, or that kind of thing. You can see the improving trend between 1980 and 1985, and again, the tough goal the industry has set for 1990.

Incidentally, the DuPont Corp. has the best record in the industry, if not in the world, with this kind of thing.

Collective radiation exposure per nuclear unit at boiling water reactors was 1,230 manrems in 1980. As an industry, we had that down to 800 by 1985, and again, set a tough goal for 1990.

Personnel exceeding 5 rems in a year——Federal regulations require that personnel be kept below 12 rems. We established 5 rems as a standard of excellence. We set that goal in 1980, and you can see the industry's progress in getting down to zero in 1984, and maintaining the zero level in 1985.

Low-level solid radioactive waste per pressurized water reactor unit. This is the pasteboard and the clothing and the paper and so on that has to be compacted and shipped off for burial in South Carolina, or one of the other low-level radioactive waste burial sites. Again, good progress between 1980 and 1985, and again a tough goal.

This goal, by the way, would have the industry doing better than the legislation passed late last year would require.

The last one of these I will show is equivalent availability, which is probably the best overall measure of plant reliability. Progress has been slow in this indicator. We did see some improvement in 1985, despite the fact that the TVA's units were shutdown and other units were shutdown. The industry has set a tough goal in 1990.

I personally am optimistic that we will see this also begin an improving trend, as we have for the other indicators, in the years to come.

In closing, the U.S. nuclear industry took the initiative to establish an organization that promotes excellence in all phases of plant operation. We have put that organization in place, and in the first 6 years have implemented the Kemeny Commission recommendations for lessons learned from TMI, that are under our jurisdiction, and we will surely apply the lessons learned from Chernobyl.

Progress has been achieved on many fronts and yet much remains to be done. We believe the foundation is in place for further progress. The National Academy for Nuclear Training is a vital part of that foundation. The payback from improved training is now being seen.

We are and will remain unrelenting in our quest for excellence and we appreciate your interest and support.

[The prepared statement of Dr. Pate follows, attachments have been retained in committee files:]

Testimony

to

the Energy and Natural Resources Committee

by

Dr. Zack T. Pate

President and CEO

Institute of Nuclear Power Operations

on

June 19, 1986

Good morning, my name is Zack T. Pate, President and Chief Executive Officer of the Institute of Nuclear Power Operations (INPO) in Atlanta, Georgia.

This testimony includes information on the formation of the Institute, its organization and mission, and three key areas germane to recent events that affect the U.S. nuclear power industry. These three areas include nuclear plant performance measures in the U.S. utility industry, the National Academy for Nuclear Training, and the Institute's International Program.

## BRIEF HISTORY OF INPO

INPO was formed by the U.S. nuclear utility industry in late 1979 to promote high standards of safety and reliability in the operation of the nation's nuclear electric generating plants. The function of the Institute is to assist utilities in the technical aspects of nuclear power plant operation. The Institute is not to be an advocate of nuclear energy.

Since 1979, INPO has grown from a small cadre of loaned nuclear utility professionals to an established work force of more than 400 permanent and on-loan employees.

Every utility in the U.S. that has a nuclear plant in operation or under construction is a member. INPO has had support from 100 percent of the nuclear utilities since its formation.

Utility organizations representing 13 non-U.S. countries make up the International Participant Program, which I will describe in more detail later in this testimony. Additionally, major supplier organizations from the United States and abroad participate through a separate Supplier Participant Program.

In forming INPO, the industry responded positively and decisively to the accident at Three Mile Island. The President's investigatory commission on that accident, the Kemeny Commission, in issuing its recommendations in October 1979, made it clear that the nuclear utility industry must be in charge of its own destiny. The commission suggested that the industry establish its own safety standards and an organization to conduct independent evaluations. INPO, formed and supported by the U.S. nuclear power industry, fills this role. A number of other Kemeny Commission recommendations that became a part of INPO's jurisdiction have been implemented. Several are referenced later in this testimony.

The accidents at Three Mile Island seven years ago and more recently in the Soviet Union make it quite clear that we must work together not only in the U.S., but as an international community to ensure the safe stewardship of nuclear energy worldwide.

We respectfully request that the four items attached to this testimony be included in the Committee record. For your reference, these include the following:

- Institutional Plan for the Institute of Nuclear Power Operations, a 1985 document describing INPO's organization, mission, and activities in depth
- INPO's 1985 Annual Report, Focus on Performance, which describes improvements in the nuclear industry as measured by selected indicators of plant performance

- The June 1986 folder entitled Performance Indicators for the U.S. Nuclear Utility Industry, updating the above reference
- The brochure and charter of the National Academy for Nuclear Training, which was established in late 1985 as the framework unifying the nuclear training efforts of the industry, the National Nuclear Accrediting Board, and INPO

## INPO ORGANIZATION

The Institute's organization is similar to that of many U.S. corporations. The Board of Directors is made up of 11 utility executives and senior managers who are elected by the members to oversee INPO's operations and activities. As a part of the Institute's charter, two of the 11 Board members must have had recent and direct responsibility in nuclear plant operation.

An Advisory Council of professionals from outside the industry reviews Institute activities and provides advice on broad objectives and methods to the Board of Directors. The Advisory Council is comprised of 18 distinguished professionals in areas related to the Institute's activities and includes prominent educators, scientists, industrialists, and health specialists.

An Industry Review Group (IRG), made up of senior professionals and managers from member utilities, is established for each technical group. These IRGs provide advice and feedback to the head of the respective INPO group. The IRGs may also be requested to conduct specific review or audit functions by the president or the Board of Directors.

The President of INPO reports to the Board of Directors and is fully and solely responsible to the Board for the operation of the Institute.

The professionals working at INPO have brought with them many years of nuclear power experience from the utility industry, the nuclear Navy, and related industries. INPO is a high standard organization, dedicated to assisting member utilities in striving for excellence in nuclear power plant operation.

## FOUR CORNERSTONE ACTIVITIES

The Institute's major technical programs can be divided into four areas, as follows:

- the evaluation of operating nuclear plants
- the analysis of nuclear plant events and the dissemination of operating experience (lessons learned) among nuclear utilities
- training and accreditation
- assistance to members and participants

## EVALUATIONS

In-depth evaluations are conducted at operating U.S. nuclear plants. On-site evaluations of plants and of corporate support activities focus on safety and reliability. The evaluations are performance-based, focusing on observations of station personnel at work. Identification of the root cause of any problem area is stressed.

Plants are placed in the evaluation schedule after reaching commercial operation; plant evaluations are scheduled in approximately 15-month intervals, while corporate evaluations are scheduled for alternate plant evaluations. INPO is now in its fifth round of evaluations for most nuclear plants. As of June 1, 1986, the Institute had completed 227 plant evaluations and 62 corporate evaluations.

Evaluations are conducted by teams of experienced professionals, augmented with industry personnel. Industry observers often accompany teams to see methodologies in place at other plants. These evaluations also often serve as a mechanism to check on the progress of other INPO programs, such as the implementation of operating experience recommendations, data reporting, and success in the implementation of training programs.

In all cases, written commitments for recommended improvements are obtained from the utility before the evaluation process is considered complete and a formal report is issued to the utility.

### Plant Evaluations

Plant evaluations include in-depth reviews of the following areas:

- organization and administration
- operations
- maintenance
- technical support
- training
- radiological protection
- chemistry
- operating experience

Plants are evaluated against a set of performance objectives and criteria developed and refined with industry input. Performance objectives reflect excellence in each operating area. In addition, INPO evaluates the effectiveness of simulator training, including operator performance during simulated emergencies and off-normal events.

## Corporate Evaluations

Evaluations of corporate support activities cover the following areas:

- organization and administration, including management involvement
- materials and outside services
- technical services
- licensing and regulatory matters
- design engineering
- document control
- human resources
- nuclear safety assessment
- quality programs
- industrial safety
- training and qualification
- radiological protection
- chemistry
- emergency preparedness

These areas are evaluated against performance objectives and criteria for corporate support that are designed to promote excellence in plant operations.

INPO determines whether the responsibilities of a utility's organizational structure are clearly defined and if all aspects of nuclear support are covered. An assessment of corporate monitoring of station performance is included, as is the degree of management involvement and commitment in supporting safe and reliable station operations. The INPO corporate evaluation teams are augmented by senior executives from other utilities.

## Construction Project Evaluations

INPO recently concluded its evaluation program for nuclear construction projects. These evaluations covered organization and administration, design control, construction control, project support, training, quality, and test control. The staff completed 21 evaluations, with each construction project being visited at least once. The Institute is now completing development of construction project guideline documents to capture the experience gained through this program.

## Evaluation Process

The evaluation process itself includes the following aspects:

- Two weeks are spent at the plant and one week at the company's corporate offices so that the results can be coordinated and the corporate evaluations can follow up on concerns found at the plant.

- Observations are made of ongoing activities at the plant in all performance areas. The teams look for the root cause of each performance problem.
- Interviews are conducted with all levels of plant personnel and senior- and middle-level corporate management.
- Rigorous follow-up is conducted on evaluation findings from earlier visits to ensure that corrective actions remain effective.
- A formal exit meeting between senior utility (typically the CEO and senior nuclear line management) and INPO management is conducted to review evaluation findings. In these meetings, key areas requiring attention are clearly called out in the candid discussions.
- Next, a written report is prepared and provided to the utility that includes findings, recommendations, and the utility responses.
- A six-month progress report is submitted by the utility for INPO's review.

Since its inception, INPO's evaluation program has been upgraded in several ways. For example, senior reactor operators from other plants now accompany each INPO team to provide current hands-on operational experience. Also, senior utility executives now accompany each corporate evaluation team as observers and advisors.

### Emergency Preparedness

INPO promotes a high degree of readiness throughout the industry so utilities are able to respond rapidly in the event of a plant emergency. Assistance is provided to member utilities in developing and maintaining effective emergency preparedness programs.

INPO's assistance to the industry in this important area has undergone considerable refinement. Initially, programmatic reviews of emergency preparedness were conducted as utilities upgraded their programs following Three Mile Island.

In 1984, the emphasis shifted from programmatic reviews to the actual observation of utility emergency preparedness drills and exercises. During these drills and exercises, a utility's procedures and resources for responding to emergencies are tested during a simulated emergency. This helps ensure that emergency equipment and facilities will function when they are needed and that emergency response personnel will work as a team in the event of an actual emergency.

## EVENT ANALYSIS AND INFORMATION DISSEMINATION

### Analysis of Events

The Kemeny Commission stressed the need for a systematic gathering, review, and analysis of nuclear power plant operational experience. INPO has been engaged in this important activity since its inception. Presently, between 7,000 and 10,000 operational reports are screened each year. For example, in 1985, 8,162 operational reports were reviewed. From this extensive information, lessons are distilled that allow the personnel at individual plants to learn from the operating experience of the entire industry.

Events are screened for significance, and those with generic applicability are disseminated to the industry in one or more of the following forms:

- o Significant Operating Experience Reports
- o Significant Event Reports
- o Operations and Maintenance Reminders
- o Industry Safety Reports
- o INPO special reports
- o Workshops and seminar presentations

Of the number reports screened, some are identified as significant in terms of nuclear safety or operational reliability. The criteria for selecting these significant events have remained essentially the same since 1981. There were 1.64 of these events per operating domestic reactor in 1981. This level has declined steadily. In 1985, 0.53 significant events per operating domestic reactor occurred. This threefold reduction in the number of undesirable significant events is an example of the effectiveness of the improvements put in place since the accident at Three Mile Island.

When an operating event has significant safety implications for the entire industry, INPO will comprehensively investigate and analyze the event. The results incorporate recommendations, in the form of Significant Operating Experience Reports, which assist utilities in preventing such events from occurring again. Since first issuing these reports in 1980, a total of 61 have been developed and distributed to INPO members and participants. These reports are color-coded to aid in setting priorities for the associated recommendations. The following color-coding system is used:

- o Red-tab operating experience reports are for immediate attention. These reports cover events that may result directly in the loss of means to effectively remove reactor heat, inability to shut down the reactor and maintain it in a shutdown condition, or extensive release of fission products to the environment.

- Yellow-tab operating experience reports are for prompt attention.
- Green-tab operating experience reports are for normal attention.

Each Significant Operating Experience Report has several recommendations, and action on these recommendations is formally tracked by each utility. During plant evaluations, the INPO team checks to determine how the utility has responded to and implemented each specific recommendation. The current status of industrywide response to completing actions on significant analysis recommendations is as follows:

- Red operating experience reports
  - 90 percent of required actions have been completed industrywide
- Yellow and green operating experience reports
  - 84 percent of required actions have been completed industrywide

The implementation status of each recommendation is tracked until appropriately dispositioned.

## Information Exchange

The Kemeny Commission also identified the need for coupling the analysis of operating experience with an industrywide international communications network. NUCLEAR NETWORK is an international electronic messaging system that fulfills this need. About 1,200 messages are routinely sent among INPO members and participants each month, covering many categories of information. Operating experience information is one important category that is promptly disseminated on NUCLEAR NETWORK.

## Nuclear Plant Information Data Bases

INPO catalogs other types of plant information and scans this information to spot any undesirable trends before they lead to serious incidents. One of the more important of these data bases is the Nuclear Plant Reliability Data System (NPRDS). NPRDS now contains engineering information for more than 4,000 components per commercial operating unit in the United States. With more than 100 such reactors in service, this data base has on file detailed engineering information for more than 400,000 of the most important hardware components in U.S. operating plants.

When one of these components malfunctions, a report is sent to INPO electronically by the plant where the malfunction occurred. This report identifies the type of failure and its cause. Currently, about 44,000 such equipment malfunction reports are on file in INPO's computers. The resulting data are accessible from remote terminals at each nuclear plant and at each corporate headquarters by INPO members and participants. This massive data base is now beginning to be used for the improvement of component and system reliability and enhancement of nuclear plant performance.

Two examples of using NPRDS information to improve component performance are as follows:

- Two plants operated by a utility experienced several essential electrical system inverter failures over a nine year period, some of which caused plant scrams and challenged safety systems. After searching the NPRDS data base and reviewing inverter failure information, the following key items were identified:

  - Many other plants had inverter failures but most did not result in a plant scram, pointing to a potential design problem.
  - The inverter failures due to heat-related component degradation were significantly higher than at other plants, pointing to a potential environmental or application problem.

  The utility initiated immediate and long-term corrective actions related to the design and environmental issues. No plant scrams from inverter failures have occurred in the year after these corrective actions were initiated.

- A plant experienced frequent failures of the isolation valves for the pressurizer power-operated relief valves, resulting in unscheduled repair outages and the increased potential for adverse impacts on plant operation. A search of the NPRDS data revealed the following key items:

  - The isolation valves had a unique design for body to bonnet closure, pointing to a potential design problem.
  - Other plants were not experiencing similar failure modes for the isolation valves.

  The utility initiated several corrective actions covering valve modifications, maintenance procedures, and training of personnel involved in valve maintenance. The valves have exhibited a significant improvement in reliability since implementation of these actions, resulting in an estimated annual increase of 0.3 percent in plant availability (cost benefit of approximately $900,000).

## Human Performance

In recent years, the utilities and INPO have begun the development and expansion of another important operational event data base and corrective action system. This system, called the

Human Performance Evaluation System is, in one sense, the human counterpart of NPRDS. While NPRDS catalogs the types of failures that machines can experience, utilities can use the Human Performance Evaluation System to identify, analyze, and correct human error. Virtually every comprehensive reactor safety study has highlighted the critical importance of the performance of people in the safety and reliability of our nuclear installations. The Human Performance Evaluation System is a major step forward in a process called for by the Kemeny Commission.

## TRAINING AND ACCREDITATION

The Kemeny Commission recognized that training plays a key role in nuclear power plant safety and reliability. The Commission recommended the "establishment of agency-accredited training institutions for operators and immediate supervisors of operators." The Commission also stressed that "comprehensive, ongoing training must be given on a regular basis to maintain operator's level of knowledge."

After Three Mile Island, the industry launched aggressive programs to upgrade the training for nuclear power plant personnel. In keeping with INPO's mission to promote the highest levels of safety and reliability, the industry assigned the Institute the task of assisting utilities in developing, implementing, and maintaining high quality, performance-based training.

The following are specific examples of activities aimed at assisting the industry in the area of training:

- INPO has developed 17 training and qualification guidelines based on the results of a systematic analysis of job content. These guidelines outline the course content needed for the training and qualification of personnel in key nuclear power plant positions.

- Using industry expertise and experience, a detailed job analysis, followed by a detailed task analysis, has been conducted for key nuclear plant positions. Job and task analysis is a proven, systematic method of determining training requirements for a specific position. It is a key step in developing comprehensive, performance-based training programs. Job analysis determines the tasks performed by each position, and an analysis of these tasks determines the knowledge and skills needed for each position.

- INPO has also developed good practice documents to assist utilities in conducting more effective training. These documents cover the following:
  - development and implementation of on-the-job training programs
  - incorporation of operating experiences into training programs
  - development of teamwork and diagnostic skills

- The Institute sponsors workshops and special seminars for utility training personnel to assist them in developing their own training systems. Training and accreditation is often a major subject at other workshops such as those for utility chief executive officers, nuclear plant managers, and the other technical disciplines.

- During regular plant evaluations, the effectiveness of training programs are evaluated by assessing the performance of plant personnel. INPO observes and evaluates the actual application of the knowledge and skills taught in the classroom and in simulator training. INPO/industry teams assess how simulator training programs teach operators to respond under different plant conditions.

- During 1985, INPO conducted 49 special training assistance visits to help utilities improve training. Through May 1986, there have been 42 such visits. Our efforts during these visits range from identifying problems to assisting in the actual development of training programs.

As a condition of membership, each of INPO's 55 member utilities has committed to achieving and maintaining accreditation of training programs for 10 key positions involved in nuclear power operations. These training programs are as follows:

- non-licensed operator
- reactor operator
- senior reactor operator/shift supervisor
- shift technical advisor
- instrument and control technician
- electrical maintenance personnel
- mechanical maintenance personnel
- chemistry technician
- radiological protection technician
- technical training for technical staff and managers

The accreditation process has three steps:

- First, using the INPO-developed accreditation objectives and criteria, the utility performs a self-evaluation to identify and correct weaknesses in its training programs. The utility writes a comprehensive report, which is provided to INPO, that describes how the accreditation criteria are being met.

- Second, an accreditation team, composed of training experts from INPO and other utilities, visits the plant and evaluates the training programs. After the utility corrects identified weaknesses, the team's recommendations, along with the utility's responses and corrective actions, are presented to the National Nuclear Accrediting Board in a written report.
- Third, the decision to award or defer accreditation is made by the National Nuclear Accrediting Board.

The National Nuclear Accrediting Board is the independent decision-making body that awards or defers accreditation of utility training programs. The Board operates under the auspices of INPO, but it is totally independent in its deliberations and decision-making process.

When training programs are presented to the Board, members examine the report of the accreditation team and the utility's responses, as well as the utility self-evaluation report. The Board's final decision comes only after its meeting with representatives from the plant and training staffs. This is a meeting that involves page-by-page review of the written report, and it is followed by private deliberations by the Board to determine whether the training programs meet the accreditation objectives and criteria.

To maintain accreditation, INPO requires a status report two years after training programs are accredited. Further, each program must be fully reaccredited every four years.

The National Nuclear Accrediting Board includes four categories of membership: senior utility representatives, non-nuclear training experts, representatives from the post-secondary educational community, and individuals nominated by the U.S. Nuclear Regulatory Commission (NRC).

A working board of five individuals meets to consider accreditation for each nuclear plant's training programs. This working board includes one or more individuals from each of the classifications listed above and must have a majority of representatives from outside the nuclear utility industry.

Members of the full Board are listed below:

## NATIONAL NUCLEAR ACCREDITING BOARD

### Non-nuclear Industrial Training Category

John E. Carroll
Vice President, Flight Standards and Training (retired)
United Airlines

Edward R. Jones, Ph.D.
Chief Human Factors Engineer
McDonnell Douglas Corporation

George E. Moore
Director, Education Department (retired)
Westinghouse Electric Corporation

Charles J. Sener
Assistant Vice President (retired)
Bell Communications Research, Inc.

### Post-secondary Education Category

William R. Kimel, Ph.D.
Dean, College of Engineering
University of Missouri-Columbia

Russell R. O'Neill, Ph.D.
Dean Emeritus, Engineering and Applied Science
University of California, Los Angeles

John M. Palms, Ph.D.
Vice President for Academic Affairs
Emory University

Robert L. Seale, Ph.D.
Head, Department of Nuclear and Energy Engineering
University of Arizona

### Utility Category

Dennis E. Gilberts
Senior Vice President, Power Supply
Northern States Power Company

John M. Griffin
Senior Vice President, Energy Supply
Arkansas Power & Light Company

Wayne H. Jens, Ph.D.
Vice President, Nuclear Operations (retired)
The Detroit Edison Company

A. Lee Oxsen
Vice President, Nuclear Operations
Boston Edison Company

Harold B. Ray
Vice President and Site Manager
Southern California Edison Company

Cordell Reed
Vice President
Commonwealth Edison Company

Donald F. Schnell
Vice President, Nuclear
Union Electric Company

C. O. Woody
Vice President, Nuclear Energy
Florida Power & Light Company

## NRC Nominee Category

Lincoln Clark, Jr.
Associate Director of Nuclear Reactor Laboratory and Director of Reactor Operations
Massachusetts Institute of Technology

Frank C. Fogarty
Associate General Manager, Experimental Programs
EG&G Idaho, Incorporated
Idaho National Engineering Laboratory

Forrest J. Remick, Ph.D.
Associate Vice President for Research
Pennsylvania State University

Gordon E. Robinson, Ph.D.
Professor, Nuclear Engineering
Pennsylvania State University

## NATIONAL ACADEMY FOR NUCLEAR TRAINING

Since the Three Mile Island accident, there have been extensive improvements in training initiated by utilities and encouraged and facilitated by INPO and the accreditation process. As a logical next step, the National Academy for Nuclear Training was established to strengthen and unify industry efforts to pursue excellence in training. The Academy provides a framework to integrate the training-related activities of nuclear utilities, INPO, and the National Nuclear Accrediting Board. It serves also to enhance the pride and professionalism of plant personnel and to aid utilities in obtaining recognition for their training accomplishments.

Since all nuclear utilities have made a commitment to achieve accreditation of their training programs, all are, therefore, provisional members of the Academy. When its first programs are accredited, a plant becomes a branch of the Academy and is authorized to award Academy certificates to graduates of its accredited programs.

As of June 15, 1986, there were 40 Academy branches, with 186 programs accredited at those branches. A utility becomes a member when all of the 10 programs at its operating plants are accredited. As of June 15, 1986, there were three members of the Academy. All of INPO's member utilities have designated senior management personnel to serve as their Academy representatives. INPO's Group Vice President for Training and Education serves as the Academy's Executive Director. He is advised by the Academy Council, which consists of 10 utility executives and managers. INPO provides administrative support for the Academy.

### Chronology of Training-related Events Leading up to the Formation of the National Academy for Nuclear Training

- A formal institution for the accreditation of nuclear plant training programs was first suggested by the President's Commission on Three Mile Island--the Kemeny Commission--in 1979.

- On December 7, 1979, the President of the United States, in his response to the Kemeny Commission recommendations, encouraged INPO, with assistance from the Department of Energy (DOE), to develop a program for upgrading and accrediting training.

- In March 1980, the President appointed the Nuclear Safety Oversight Committee, chaired by Governor Bruce Babbit of Arizona. The Committee recognized INPO's programs as a suitable approach to implementing the Kemeny Commission recommendations.

- In September 1980, INPO formed a task force to review the question of whether training centers should be located at each utility or established on a regional or national basis. The purpose of the study was to help INPO determine how to structure its accreditation program. The task force recommended (in March 1981) in favor of local, utility-based training centers. There were three reasons for this recommendation, as follows:

- Every plant's operators need to train on a plant-specific (or plant-referenced) simulator.
- Recurrent or requalification training is best conducted at the trainee's plant, since virtually every plant in the United States is unique.
- On-the-job training can be integrated with classroom studies more effectively.

o Congress enacted the "Nuclear Safety Research, Development and Demonstration Act of 1980." The act directed the Secretary of Energy to consider the establishment of a national academy to train nuclear professionals. The DOE report (in December 1981) concluded that existing efforts at INPO and in the nuclear utility industry could meet the goals for enhanced operator training.

o In May 1982, INPO published and implemented procedures and criteria for accreditation that reflected the following approach:

- Training is controlled and conducted locally by utilities.
- Training activities are evaluated by INPO.
- Training programs are accredited by an independent accrediting board.

o Section 306 of the Nuclear Waste Policy Act of December 1982 directed the NRC to promulgate regulations or regulatory guidance for the training and qualification of nuclear power plant personnel. After considerable review, the NRC issued a Policy Statement on Training and Qualification of Nuclear Plant Personnel that endorsed the INPO-managed accreditation program and gave the industry a two-year period to show progress. The policy statement was dated March 1985.

o Early in 1985, Senator Moynihan (D-NY) introduced Senate Bill 16, "The National Nuclear Power Plant Personnel Training Act of 1985," which would have established a National Academy for Nuclear Power Safety.

o In early 1985, INPO began developing the concept of an industrywide academy that would integrate the following three elements:

- extensive utility training facilities and staffs
- the independent National Nuclear Accrediting Board
- the training-related activities of INPO

- In May and June of 1985, the INPO Board of Directors discussed the formation and structure of this National Academy for Nuclear Training.
- In September 1985, the INPO Board of Directors approved and established the National Academy for Nuclear Training.

Certificates of achievement are now being awarded to individuals who successfully complete accredited training programs; further, plants receive recognition when they are designated as Academy branches, and utilities are recognized when they are designated as Academy members.

Although the Academy is less than a year old, it has received recognition from public officials as having significant potential for industry improvement.

In a November 6, 1985, letter to Senator Moynihan, NRC Chairman Palladino stated (in part):

> ". . .the INPO proposal for a National Academy for Nuclear Training. . .is a natural extension of the industry initiatives in the training area. If the Academy is able to carry out its stated objectives of focusing and unifying the industry's training efforts, it should have a beneficial effect on overall reactor plant safety."

At the Atomic Industrial Forum/American Nuclear Society meeting on November 13, 1985, Secretary of Energy Herrington noted:

> "The decision by the Institute of Nuclear Power Operations to establish a National Academy for Nuclear Training. . .is an outstanding example of. . .industry action showing . . .that we're serious about safety by doing everything possible to ensure safe and reliable operation of nuclear plants."

Former White House Science Advisor George Keyworth, in an address to the Atomic Industrial Forum in December 1985, stated that:

> "INPO has been aggressive in developing training programs to make sure the personnel--who are the heart of any operating reactor--are well-trained. . .and certified as to their qualifications. It's an impressive array of programs, including the new National Academy for Nuclear Training. . ."

These statements indicate that the Academy has been recognized as a positive industry initiative by the NRC, the Department of Energy, and a key member of the Administration.

Further information on Academy organization and operation is provided in the charter and the brochure that are attached to this testimony.

## ASSISTANCE

The industry recognized that a fundamental element in striving for operational excellence was to promote the exchange of information and good practices among members and participants and to assist member utilities in implementing their own improvements. INPO conducts special assistance visits to member utilities and international participants as requested and agreed to by the Institute. These are independent of INPO's evaluation and accreditation programs (though a request for such visits frequently stems from an evaluation) and are intended solely to assist the membership in improving operational safety and reliability.

The Institute provides other direct assistance through many forms of written and computerized information. This program is important in helping utilities learn not only from each other's experiences, but also from the best elements of programs in the industry.

INPO's assistance to members includes the following specific activities:

- On-site visits: Assistance visits requested by the utility to cover specific areas. This area has seen the expanded use of industry "subject matter experts" to increase the technical expertise of the assistance teams, with assistance based on sharing best practices. INPO's activities in this area have increased steadily, with teams conducting 102 special assistance visits to 39 utilities in 1985.
- Requests for information: INPO is responsive to many requests for information regarding successful programs. The Institute acts as a clearing house for sharing documents, procedures, methods, etc.
- Guidelines: These documents are publications that establish the basis for sound programs in selected areas of nuclear plant management, operation, and training. They are provided to member utilities to aid them in developing or improving the management and operation of their plants, and most are designed to assist member utilities in meeting INPO performance objectives and criteria. It is expected that utilities may use different approaches or methods than those defined in the guidelines, but members are expected to meet the intent of the guidelines.
- Good Practices: A good practice is one effective method for enhancing nuclear power plant management and operation. Good practices are written to address many areas of plant operation. INPO has developed good practices based on elements of the better industry programs and procedures

identified during INPO evaluations, assistance visits, and workshops. They are periodically reviewed and updated to ensure continued applicability. To date, 88 good practices have been developed and furnished to members and participants.

- Workshops/Working Group Meetings: These information seminars are held periodically for each of the utility key managers, including the plant managers and chief executive officers. The use of workshops and meetings contribute substantially to INPO's mission. They are widely attended by members as well as supplier and international participants. The attendees not only benefit from the information presented but also from the exchange of information through discussions with their counterparts from other utilities. Since INPO's founding, over 60 workshops have been conducted, with nine scheduled for 1986 and 10 planned for 1987.

## INPO'S RELATIONSHIP WITH OTHER ORGANIZATIONS

In carrying out its mission to promote the highest levels of safety and reliability in the operation of nuclear electric generating plants, INPO depends on the support of its members and participants and on the coordination of its activities with other industry organizations and groups, as well as with various federal agencies.

The principal industry organizations and groups with which INPO maintains liaison include the Atomic Industrial Forum (AIF), American Nuclear Energy Council (ANEC), American Nuclear Society (ANS), American Public Power Association (APPA), U.S. Committee for Energy Awareness (USCEA), Edison Electric Institute (EEI), Electric Power Research Institute (EPRI), National Rural Electric Cooperative Association (NRECA), and Utility Nuclear Power Oversight Committee (UNPOC). Additionally, to minimize duplication of effort and to support its members, INPO maintains liaison with insurer groups such as American Nuclear Insurers, Nuclear Mutual Limited, Nuclear Electric Insurance Limited, and Mutual Atomic Reinsurance Pool.

To ensure credibility, INPO maintains its independence with respect to any individual member and with respect to federal agencies, while being responsive to the collective needs of the nuclear utility industry. The Nuclear Regulatory Commission (NRC) is the principal federal agency with which INPO coordinates its programs. The Institute needs to coordinate its activities and cooperate with the NRC while at the same time neither becoming nor appearing to become either an extension of the NRC or an advocate for the utilities. As a result, INPO and NRC activities must be largely independent, yet complementary.

INPO expects that the NRC will review INPO programs and provide appropriate regulatory credit. A Memorandum of Agreement has been established with the NRC that covers key areas in which NRC and INPO have mutual interests. This agreement establishes the framework for cooperation and coordination, including the sharing of information. For example, INPO provides the NRC information on INPO programs and activities, including the following:

- copies of selected generic documents
- access to other pertinent information as described in specific coordination plans
- periodic briefings
- observation of INPO field activities by NRC employees (with agreement of the member)

INPO also coordinates its activities with the Department of Energy (DOE) and has a Participation Agreement in place. In addition, certain aspects of the Institute's International Program are coordinated with the Department of State.

Additional details on INPO's interactions with outside organizations and groups are provided in the attached Institutional Plan.

## INDUSTRY PROGRESS

The success of the Institute's programs can best be measured by the progress of the industry. The programs explained previously support the industry's efforts to improve performance in nuclear plant safety and reliability. As the needs of the industry have evolved, activities in each of the four cornerstone areas have undergone refinement in scope and philosophy. As utilities focused their attention on nuclear plant performance, the Institute's goal was to make sure its programs and activities provided the best possible support for these efforts.

### Training

The importance of training in the nuclear industry cannot be overemphasized. Training of all personnel employed in nuclear plants has improved over the past several years; however, the extent to which improved plant performance can be attributed to upgraded training may not be fully evident for another few years. The trainees in the training programs accredited today will not be impacting plant performance until they graduate and begin performing independently.

However, the results of increased training emphasis are already beginning to be felt in the plants. Plant managers have stated that they are seeing better performance in the plant as a result of upgraded training, and there have been several instances of undesirable plant events that were prevented as a direct result of specific training that was provided. There is also an increased awareness at all levels of management regarding training and the benefits to be gained from improved training.

Among the training advancements INPO has seen are the following:

- In 1979, there were 10 training simulators in the industry. Currently, 52 are in operation, and when those planned or under construction are completed, 75 will be in operation.
- The number of operating shifts in the industry has increased, with 42 plants having six shifts (55 percent of the industry) and 34 plants having five shifts. This compares with four shifts at many plants in 1979 and allows for one shift to be dedicated to training and requalification at all times.
- Floor space dedicated to training has quadrupled since 1979. Utilities now have more than 2.2 million square feet of training space dedicated to nuclear plant personnel training and some 813,354 square feet of additional training space is under construction.
- Ten years ago, a typical nuclear plant training staff consisted of one coordinator and a handful of instructors. Today, an average of 24 instructors and five additional training professionals are at work at each nuclear plant in the country--four times as many as in 1980.

## Plant Performance Indicators

In early 1981, INPO initiated development of a performance indicator program in order to strengthen and support utility efforts in attaining high levels of performance.

It is widely recognized that nuclear plants with high equivalent availability, small numbers of forced outages, few unplanned scrams, few significant events, and low personnel radiation exposures are generally well-managed overall. Such plants are more reliable and can be expected to have higher margins of safety. Therefore, the performance indicator program and its use by utilities in establishing long-term goals directly support improvements in plant safety as well as reliability. In 1985, in recognition of this, INPO, in conjunction with three external ad hoc review groups, looked closely at how performance indicators could be best utilized to enhance long-term improvement.

Ten overall indicators were ultimately identified as the good measures of nuclear power plant performance. INPO's member utilities are now tracking their performance in these areas and establishing long-term goals in most of them. All began reporting data to the Institute during 1985. INPO analyzes this data and provides periodic reports to members and participants.

In April 1986, INPO issued its initial periodic Industrywide Nuclear Power Plant Performance Indicator Report representing data reported by member utilities. The report reflects industry results through calendar year 1985 and presents those results in a manner that allows comparison of a specific utility's performance with that of the industry as a whole. Among the indicators in the report are the following:

- equivalent availability factor
- safety system unavailability
- unplanned automatic scrams while critical
- unplanned safety system actuations
- forced outage rate
- thermal performance
- fuel reliability
- collective radiation exposure
- volume of low-level solid radioactive waste
- industrial safety lost-time accident rate

The remaining indicators in the report reflect performance in specific areas such as maintenance, chemistry, and radiation protection. Data on these indicators are provided to utilities as management tools for assessing performance.

Attached to this testimony is a folder entitled Performance Indicators for the U.S. Nuclear Utility Industry, dated June 1986. This shows utility industry performance results for the overall indicators for the years 1980-1985. As can be seen from a review of the graphs, improving trends are evident in a number of areas including the following:

- The number of unplanned automatic reactor scrams while the reactor was critical has declined by more than 41 percent since 1980, from an estimated 7.4 per unit down to 4.3 per unit in 1985.

- The number of significant events per unit (identified through the INPO Events Analysis Program) at U.S. operating nuclear plants has declined over 67 percent since 1981, from 1.64 to 0.53 in 1985.

- Forced outage rates reflect the percentage of time units are off-line on short notice because of equipment failures or other conditions. This outage rate has dropped more than 26 percent since 1982, down from 16.1 percent per unit to 11.9 percent per unit in 1985.

- Equivalent availability is the ratio of the total power a unit could have produced, considering actual equipment and regulatory limits, to its rated capacity expressed as a percentage. Equivalent availability has risen from 59.8 percent in 1980 to 63.5 percent in 1985.

- Collective radiation exposure for pressurized water reactors (PWRs) has dropped by nearly 40 percent since 1981 when it reached a high of 707 man-rems per unit-year. It was only 425 man-rem per unit-year in 1985. For boiling water reactors (BWRs) it has decreased almost 35 percent since 1980 from 1,230 man-rem per unit-year to 800 to 1985.

- Low-level, solid radioactive waste shipped per PWR unit has been reduced more than 43 percent, from 586 cubic meters per unit-year in 1980 to 334 in 1985. For BWRs, it declined more than 28 percent, from 1,113 cubic meters per unit-year in 1980 to 797 in 1985.

- Industrial safety initiatives have reduced lost-time accident rates for worker injuries at nuclear plants by almost 53 percent since 1980 (1.36 per 200,000 man-hours worked in 1980 to 0.64 in 1985). This fact alone makes the U.S. nuclear power plant one of the safest industrial work places.

## LONG-TERM GOALS

In conjunction with ongoing efforts to monitor performance, INPO has been working in concert with the industry to encourage each utility to use the overall performance indicators to establish long-term goals for each of its nuclear units.

Throughout 1985, INPO interacted with members and participants to refine the overall performance indicators and to develop background information that would assist in establishing long-term goals for each unit. This effort culminated in discussions at the November 1985 CEO Workshop where each utility was asked to establish 1990 goals for as many of the overall indicators as feasible and provide those goals to INPO during the spring of 1986.

By April 1986, each utility with operating nuclear plants had developed 1990 goals for most of the overall indicators. The following is a table that reflects these goals and that shows how they compare with 1980 and 1985 results.

## 1990 AVERAGE GOALS

| OVERALL PERFORMANCE INDICATORS | 1980 VALUE | 1985 VALUE | 1990 AVERAGE GOAL |
|---|---|---|---|
| Equivalent Availability Factor (percent) | 59.8 | 63.5 | 76 |
| Unplanned Automatic Scrams While Critical (per unit-year) | 7.4 (estimated) | 4.3 | 1.5 |
| Unplanned Safety System Actuations (per unit-year) | * | 1.3 | .8 |
| Forced Outage Rate (percent) | 11.4 | 11.9 | 5 |
| Collective Radiation Exposure (man-rem per unit-year) | | | |
| PWR | 597 | 425 | 288 |
| BWR | 1230 | 800 | 469 |
| Volume of Low-level Solid Radioactive Waste (cubic meters per unit-year) | | | |
| PWR | 586 | 334 | 213 |
| BWR | 1113 | 797 | 466 |
| Industrial Safety Lost-Time Accident Rate (per 200,000 man-hours worked) | 1.36 | 0.64 | .19 |

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*Data not collected for this indicator prior to 1985.

Establishment of these long-term goals has helped define an industry vision of desired achievement by 1990 and provides a framework for action. The response of the utilities to date in regard to this effort is indicative of the strong commitment to long-term improvement.

We consider these results to be very encouraging.

## INTERNATIONAL PARTICIPANT PROGRAM

As INPO developed and expanded its activities during 1981, an International Program was formed to exchange operating experience and technical information with participating international nuclear utilities or utility organizations in other countries.

Participation is open to non-U.S. utility organizations involved with the operation of nuclear power plants. International participants contribute to the funding of INPO so that the International Program is financially self-supporting.

The first organization to join was Electricite de France in 1981. The most recent participant is Korea Electric Power Corporation, which joined in 1983. The INPO International Participant Program has grown to include 13 countries on four continents, representing 44 utilities with 175 operating nuclear reactors. This represents 82.5 percent of the operating reactors in the free world. The 13 international participants represent the following countries:

Belgium
Brazil
Canada
England
France
Italy
Japan
Mexico
South Korea
Spain
Sweden
Taiwan
West Germany

Each participant assigns liaison engineers to INPO to facilitate information exchange between the organizations as well as to participate directly in Institute programs.

With the exceptions of actual plant evaluations and training accreditation support, international participants are eligible for the same benefits as INPO's domestic members.

The international participants provide operating experience analysis and data to the Institute's event analysis activity. They also are active participants in various workshops and other information exchange programs. NUCLEAR NETWORK, INPO's computer-based messaging system, is used widely by the International Participants. For example, the 13 participants originated more than 1,557 messages in 1985.

Technical exchange and assistance visits by INPO teams to plants operated by the international participants are now commonplace. In 1985, INPO teams made 12 such visits, including a comprehensive review of Japan's approach to nuclear plant operation by a team of 22. The visit to Japan was headed by Mr. E. P. (Dennis) Wilkinson, INPO's President Emeritus, and included team members from INPO, seven U.S. utilities, Westinghouse, General Electric, the Electric Power Research Institute and the National Nuclear Accrediting Board.

International Program activities are coordinated closely with the U.S. Department of State, the U.S. Department of Energy, and the U.S. Nuclear Regulatory Commission. In 1983, a Memorandum of Understanding was established with the International Atomic Energy Agency (IAEA) in Vienna, Austria, which also provides for coordination and information exchange. Currently a senior INPO technical manager is filling an assignment in the Division of Nuclear Safety at the IAEA.

Further, the Institute conducts periodic discussions with the Organization for Economic Cooperation and Development/Nuclear Energy Agency in Paris, France, and with the Pacific Basin Coordinating Committee. These forms of information exchange, although limited, support our more extensive interactions with the INPO international participants.

## CONCLUSION

The U.S. nuclear utility industry took the initiative to establish an organization that evaluates the performance of nuclear electric plants, and one that promotes excellence in all phases of plant operation. We have put that organization in place, and in our first six years, have implemented the Kemeny Commission recommendations--the lessons learned from TMI--that are under our jurisdiction.

Progress has been achieved on many fronts, yet much remains to be done.

We believe the foundation is in place for further progress. The National Academy for Nuclear Training is a vital part of that foundation, and the payback from improved training is now being seen.

We are and will remain unrelenting in our quest for excellence. We appreciate your interest and your support.

Senator **Domenici**. Thank you, very much. We will now hear from Dr. Richard Dean, senior vice president, GA Technologies, San Diego, CA.

## STATEMENT OF DR. RICHARD A. DEAN, SENIOR VICE PRESIDENT, GA TECHNOLOGIES, INC.

Dr. **Dean**. I appreciate the opportunity to appear before you to discuss the implication of the Chernobyl accident on the domestic nuclear industry. As accurate information becomes available, I am sure technical lessons will be learned that will be applied to our light-water reactor industry, which is already very safe, to make it even safer.

Furthermore, misconceptions and misinformation, which has been generated regarding the utilization of graphite will be corrected, and I have addressed these issues in my written statement.

Now, I would like to focus on just ways that the accident may affect the nuclear industry in the United States.

The first is a direct near-term impact, and that will be on public acceptance of nuclear power. Following Three Mile Island, when public support for nuclear power reached a low, the industry made efforts to restore the public's confidence in nuclear power, and now only to see it erode again following Chernobyl.

I do not believe we will be able to revitalize our domestic industry without strong public support, and therefore, we must take immediate action to start restoring their confidence in nuclear power.

This will be a multifaceted task. One essential ingredient in my opinion is that we rapidly develop an inherently safe reactor.

Dr. Hans Blis, the Director General of the IAEA, who you probably saw on TV following the incident at Chernobyl; he voiced a similar opinion in the opening session of the European Nuclear Conference in Geneva earlier this month when he was discussing the events and consequences of Chernobyl, and their impact on the worldwide nuclear industry.

His point was that the next generation of reactors require greater intrinsic safety, to be more forgiving, and the sooner we obtain such designs, the better.

Now while the focus on inherently safe plants for domestic use may be the near-term issue, there may be an even greater implication, although it is more indirect and of a longer term. When we look into the early part of the next century——

Senator **Domenici**. Dr. Dean, I again, apologize. The call I made did not find anybody on the other end, but they found me now, so I have to go take a call.

[A short recess was taken.]

Senator **Domenici**. Let's go.

Dr. **Dean**. Looking into the next century, the only realistic supplies of energy is coal and fission, nuclear power. The economic expansion of the Third World and the developing countries will be dependent on an adequate source of energy, and it is unrealistic to expect that this can be met by coal.

Lord Marshall of Goring, who is the Chairman of the CEGB in the United Kingdom, recently stated that we in the West intend to either attain a disproportionate share of the world's energy, or else we must introduce a major, new energy source.

He rejected the first option as unethical, and since without this new energy source, the Third World would be kept in poverty. Therefore, the development and deployment of nuclear power in these nations are essential.

Now is the current generation of nuclear plants the proper product to export to the Third World? Even from a very nationalistic point of view, I think not. Those countries simply don't have the technical infrastructure required to operate the current generation of reactors in a safe and efficient manner, nor can they afford to direct their future technical capabilities out of proportion to such a task.

It is vital that this capability be utilized for design and construction of dams and irrigation systems and transportation systems, to feed their populations. They should be insisting on systems that have improved, inherent safety and investment protection features.

But I ask, what if a serious accident in a developing country were to occur? You discussed the type of reactor going into Cuba this morning. Pressured water reactor with containment. What would be the impact of a serious accident due to solely operator error if they failed to have the technical infrastructure such as has been described by INPO hearing this morning?

I believe there would be a demand from the public and the United States to shut similar reactor types down. My message is that we can provide an inherently safe reactor for export to the developing countries not just for our own good, but to protect our ability to generate nuclear energy in the United States with the current generation of reactors.

Thus, the accident at Chernobyl calls for an acceleration of the program to develop these inherently safe reactors, such as the modular high-temperature reactor that is being restricted by its current funding level.

We appreciate the opportunity to appear before you and present our views on some of the implications that can be expected from the Chernobyl incident. Thank you, very much.

[The prepared statement of Dr. Dean follows:]

# STATEMENT SUBMITTED FOR THE RECORD
SENATE ENERGY AND NATURAL RESOURCES COMMITTEE
UNITED STATES SENATE

# THE CHERNOBYL ACCIDENT
AND
IMPLICATIONS FOR THE DOMESTIC NUCLEAR INDUSTRY

June 19, 1986

DR. RICHARD A. DEAN
SENIOR VICE PRESIDENT
GA TECHNOLOGIES, INC.

Mr. Chairman:

I appreciate the opportunity to testify this morning on the implication of the tragic Soviet nuclear accident at Chernobyl on our domestic nuclear industry. Although we may never be told the exact cause of the sequence of events at Chernobyl, I believe we are in a position to put to rest some of the misconceptions and misinformation which have been generated regarding the accident; we can identify the basic differences in the safety features of Chernobyl with those of other nuclear systems; and we can identify compelling arguments for the development of inherently safe advanced nuclear power in the United States.

In the first few days and weeks following the Chernobyl accident, the media appeared to characterize the presence of a graphite moderator in the core of the Soviet reactor as a major contributor to the loss-of-coolant accident. From what has come to light about the accident, I believe you will find now that the technical concensus is that the presence of graphite did not initiate the loss-of-coolant accident, contribute to the explosion, or to the initial dispersion of radioactivity which occured at Chernobyl.

The early identification of graphite as a trigger for the accident was very surprising, since the use of graphite in nuclear reactor designs has long been viewed as an additional safety feature when coupled with appropriate coolant and fuel design. In fact, the use of graphite as a fuel moderator is a primary safety feature in both the U.S. and German design of what is arguably the most publicly acceptable of the inherently safe advanced reactor designs, the Modular High Temperature Gas-Cooled Reactor.

Graphite, which has excellent nuclear properties, and is stable to very high temperatures, provides a large heat storage capacity, and has long been considered a means for improving reactor performance and safety. Currently, as part of the U.S. Department of Energy program, a Modular High Temperature Gas-Cooled Reactor (MHTGR) is being designed which takes advantage of these graphite properties to attain a passively safe system, i.e., the safety of the public is assured under all conditions without requiring any operator action or the operation of powered systems (such as pumps, valves, motors, etc.). In supporting this concept, the Congress has recognized that a system of this type is essential to overcome the technical and institutional barriers which have prevented the deployment of nuclear systems in the U.S., for the past decade. The need for a passively safe system, such as the Modular HTGR, is even more essential after Chernobyl.

The Chernobyl nuclear disaster has raised questions regarding the design similarities and differences between the RBMK (Chernobyl type) boiling water graphite moderated reactor and the MHTGR. In particular, the reported graphite fire has drawn attention to the MHTGR which also uses graphite as a moderator. In this testimony, I will identify the numerous fundamental differences in the safety of the two systems.

The Chernobyl RBMK reactor is a pressure-tube type of reactor using zirconium alloy clad uranium oxide pellets as fuel, boiling light water as the coolant, and graphite as the moderator (Figure 1). The fuel assemblies consist of a cluster of 18 clad fuel pins located in vertical zirconium alloy pressure tubes througn which the cooling water is circulated. The reactor is designed to perform on-line refueling. The reactor coolant inlet and outlet temperatures and pressures are consistent with boiling water reactor technology. The approximately 1700 pressure tubes which serve as the pressure boundary for the system pass through stacked graphite moderator blocks. The graphite blocks are enclosed in a thin stainless steel enclosure and blanketed with a helium and nitrogen gas mixture. The safety system incorporates an emergency core cooling system and a pressure suppression system. The reactor is surrounded by concrete and steel shielding and support structures.

The MHTGR uses ceramic coated particle fuel, helium gas as a coolant, and graphite as the moderator and core structural material. The fuel particles consist of microspheres of uranium oxy carbide clad with pyrolytic carbon and silicon carbide, which form a barrier and pressure vessel to retain fission products. These ceramic coatings are stable to very high temperatures. The coated particles are bonded together with a graphitic binder and inserted into large graphite fuel element blocks. The helium gas passes through coolant holes in the fuel element blocks. Although the coolant pressure is lower than that of the RBMK concept, the use of the inert helium as a coolant allows operation of the reactor at a higher temperature. The pressure boundary for the Modular HTGR system is a steel reactor vessel which is contained in a below-ground silo which serves as a biological shield and vented confinement structure. As indicated above, the RBMK and MHTGR are significantly different types of reactors. These differences are also reflected in their susceptibility and response to accident conditions which could lead to the release of radioactivity from the plant.

Key factors in the accident responses to the reactor system include:

### Heatup Rate With Loss of Coolant

- The heatup rate of the fuel in the MHTGR is very slow since the fuel and moderator are integral and the heatup rate is determined by the heat capacity of the massive graphite moderator.

- The RBMK heatup rate of the fuel and cladding is rapid since the heat capacity of the fuel assemblies is small and the fuel assemblies are thermally isolated from the massive graphite moderator.

## Temperature Stability

- The ceramic pyrocarbon and silicon carbide fuel particle coatings (i.e., cladding) in the HTGR are stable and retain fission products to temperatures of over 3200°F. The graphite core structure gains in strength to 4500°F and is structurally sound to over 5400°F.

- The zirconium alloy fuel cladding of the RBMK loses strength and starts release of fission products at approximately 1300°F during a loss of coolant accident.

## Chemical Reactions Between Coolant and Fuel

- In the HTGR, the helium coolant is inert and does not react with the grahite, fuel coatings, or other system components.

- In the RBMK, an exothermic (heat producing) chemical reaction between water (or steam) and the zirconium alloy fuel cladding is initiated at about 1800°F.

## Wigner Energy Release

- The buildup of Wigner energy in graphite, which can lead to a rapid buildup in temperature upon release, is not a consideration in the HTGR or in the RBMK reactor. Both reactors normally operate at temperatures at which the energy is annealed out of the graphite continuously.

## Graphite Burning

- It is difficult to induce a self-sustaining burning of the dense, massive graphite shapes used in either the

HTGR or RBMK type reactors. Studies of the graphite combustion process have shown that under ideal controlled conditions in which an ample supply of oxygen or air is available, graphite temperatures in excess of 1300°F are required. These conditions do not exist in normal operation of the systems and would be expected to result only as a consequence of a major accident(s) which could cause multiple breaches of the barrier(s) preventing air/graphite contact. To get a self-supporting reaction, a continuous flow of air must come in contact with the hottest graphite. (A double breach of the steel pressure vessel, one in the upper portion and the other in the lower portion, would be required in the MHTGR.) Further, unless a large fraction of the graphite is exposed, the amount of heat that would be generated woud be small compared to the decay heat of the core.

The accidents which would result in major releases of fission products are those which could result in a failure of the fuel cladding (or particle coatings) and the failure of the pressure boundary (pressure vessel or pressure tube). The accidents of major concern are those involving a loss or blockage of coolant for water-cooled systems and the depressurization accidents for gas-cooled reactors.

In the case of the RBMK, coolant system blockages or breaks are the most likely conditions which would lead to a loss of coolant accident. The limited heat capacity of the RBMK fuel rods (and the thermal isolation from the graphite mass) can lead to failure of the zirconium alloy clad and the release of fission products into the system in a matter of seconds. Further damage to the cooling system and/or exothermic chemical reactions (such as the zirconium water reaction) could occur which could lead to a breach of the primary pressure boundary, to radiation release from the plant, to an increase in graphite temperatures, to air ingress, and ultimately, if the geometry allows a continuous supply of air, to graphite burning.

In addition, it also appears that the RBMK reactors are susceptible to reactivity accidents (a rapid increase in power with loss of water) which could lead to rapid steam formation and the overpressurization of the system.

The loss-of-coolant accidents of concern for the MHTGR involve the depressurization of the core, along with the loss of all active means of circulating the coolant or of removing heat from the core. Since in the HTGR the fuel particles are physically and thermally coupled with the massive core and reflector graphite, the fuel temperature increases very slowly. Because of the slow heatup of the reactor and its low power density, sufficient heat can be removed from the core by passive radiation and conduction to the surroundings that the modular HTGR core temperatures never reach temperatures at which the ceramic cladding will fail or release fission products within the system.

A large sustained air-graphite reaction is also precluded since the modular HTGR is designed to be contained within a below ground silo. This type of installation limits the quantity of air that would be available to sustain an air-graphite reaction, even should a double rupture of the vessel occur and the graphite becomes exposed. Further, studies of the combustion of HTGR fuels have shown that the fuel particles retain their capability to retain fission products even if the graphite and outer pyrocarbon layer has been burned away.

Chemical reactions which could lead to an explosion are essentially precluded in the HTGR since the system remains blanketed with the inert helium coolant and the core components do not chemically react with each other. The introduction of water into the system could lead to the formation of hydrogen and carbon monoxide. The rate at which this reaction takes place is insignificant below about 2000°F (well above the temperatures normally present in the MHTGR core). Further, the reaction is endothermic (absorbs heat) and is self-limiting.

Another important safety feature of the MHTGR is the large negative temperature coefficient. Loss of cooling tests were performed at the AVR (Arbeitsgemeinschaft Verbuchsreaktor GMBH) HTGR reactor in Germany. The reactor was at 100% power and the circulators were stopped and the control rods were locked out. The increase of temperature of the fuel was sufficient to take the reactor subcritical and there was no damage to the fuel or plant.

Thus, the nature of the fuel system, coolant, and plant arrangement for the HTGR, which are dramatically different from the RBMK type system, essentially preclude the possibility of an accident such as occured at Chernobyl, and more importantly, prevent by passive means accident consequences which would result in significant release of radioactivity.

It is essential that the developing countries be provided with some form of nuclear power in the next century if they are to improve their economic condition. Is the current generation of nuclear plants the proper product for this export? I think not, because those countries cannot support the technical infrastructure required to operate these plants in a safe and efficient manner. That is not just their problem, but a problem for our domestic industry. If there is a serious accident anywhere in the world all similar operating reactors in the U.S. would come under close scrutiny and in all likelihood there would be a demand from the public to shut them down. Therefore, for our own good, we must provide an inherently safe accident-proof reactor for export to these developing countries.

The Chernobyl accident again highlights the position of this Committee that nuclear safety remains a major issue and it is of vital importance for this nation to take the lead in aggressively developing a reactor in which the safety of the public is not dependent upon active systems or human response, but rather systems in which safety is assured by passive mechanisms inherent in the concept.

We thank you for the opportunity to testify before you today and look forward to your continued support of the modular HTGR program.

Senator DOMENICI. Thank you. Dr. Beyea, senior staff scientist, National Audubon Society.

## STATEMENT OF DR. JAN BEYEA, SENIOR STAFF SCIENTIST, NATIONAL AUDUBON SOCIETY

Dr. BEYEA. Thank you, Senator. As a nuclear physicist who has many studies of reactor accidents, I appreciate this opportunity to comment on behalf of the National Audubon Society in connection with the Chernobyl accident. I will summarize my statement.

The accident, I think, has many lessons to teach us, and the first of which is that accidents are indeed serious business. I think even a conservative estimate indicates that at Chernobyl, thousands of cancers will likely result over the next 30 years, and that is using the Japanese bomb data to estimate cancer risk coefficients.

I am somewhat surprised by Mr. Taylor's comparison of the Japanese bomb with the Chernobyl release; it is comparing apples and oranges; for instance, the long-term radioactivity that dominates the reactor accident consequences, you probably have 100 times as much radiocesium at Chernobyl than at Hiroshima or Nagasaki. It is a question of sitting down with the source terms and doing the calculations.

I might add that the NRC certainly has access to computer codes that will do those kinds of calculations relatively easily if they have a rough estimate of the source term. They do that calculation when they estimate risks at domestic plants; they can do it at Chernobyl.

The second lesson I think is that strong containments are valuable safety features, and we are very fortunate in the United States, I believe, that we have many reactors with strong containments. But a significant fraction of U.S. reactors, as we have heard this morning, do not have strong containments.

Senator DOMENICI. I did not get the last remark.

Dr. BEYEA. There is a large number of U.S. reactors that do not have strong containments. In particular, the 25 older, small volume containments made by General Electric will quickly burst in a core melt situation.

I would like to add a paper, Senator, to the record that a colleague and I did that documents that statement.

In addition, even the large volume containments are not guaranteed to survive a loss of coolant accident, so I think that the Chernobyl accident is indeed relevant to the U.S. nuclear program.

The third lesson is that radioactivity from reactor accidents can travel enormous distances. Computer models have been predicting this for years, as I document in my written statement. Yet no attempts to coordinate emergency planning between countries has taken place.

In particular, the United States does not have agreement with either Mexico or Canada to deal with transborder radioactivity.

A fourth lesson is that the enthusiasm of nuclear engineers needs to be tempered by a strong regulatory process, one in which the voices of independent scientists and the public can be heard.

In light of this issue, it is distressing to me that the nuclear industry is still promoting legislation to restrict public involvement in the licensing process. What such legislation will really do is bring us closer to the regulatory system used by the Russians.

How do we respond to the accident? The National Audubon Society, like many other organizations, is trying to decide what recommendations to make in light of Chernobyl. Right now it is far too early for us to take a formal position on the implications of the accident. I thought it would be useful to share with you some of the recommendations that we are contemplating.

The first possible recommendation is to shut down those reactors with weak containments until the implications of the Chernobyl accident are thoroughly studied. That is what was done with the B&W reactors after the TMI accident, and we think maybe that is what should be done with the old General Electric reactors.

Now, the National Audubon Society, with its 500,000 members, will not recommend that all reactors be closed. To shut down all plants immediately would be to guarantee a large increase in the consumption of coal, which itself carries a drastic public health and environmental penalty. The National Audubon Society favors a gradual phase-out of nuclear power.

Nevertheless, we are very concerned about the possible implications of the Chernobyl accident for small volume containments, and that is why we are considering supporting a moratorium on these types of reactors; small volume reactors.

And fortunately, it will not be very expensive to do that, to keep those reactors shut down for a few months. Right now, we have excess generating capacity in most parts of the country, while oil and natural gas prices are low.

The second and third recommendations are discussed in my text and require very little explanation.

Senator DOMENICI. Shut them down for a few months? What would we do during the few months?

Dr. BEYEA. We would evaluate the Chernobyl accident for its implications to the domestic industry.

Senator DOMENICI. I thought we were going to fix them; that is not going to be done in 2 or 3 months.

Dr. BEYEA. I don't think we can do that in a few months. I think it takes several months to understand the full implications of the Chernobyl accident.

The second and third recommendations we are considering are, emergency plans should be revised to include dose reducing measures beyond 10 miles, and in particular, arrangements should be made with Canada and Mexico to handling the difficult planning tasks associated with radioactivity crossing national boundaries.

The next recommendation we are considering is that all attempts to weaken public involvement in reactor licensing should be halted and that public participation should be made more meaningful by funding intervenors.

A final recommendation we are considering does require some explanation. This is a recommendation to impose a 1-cent-per-kilowatt-hour tax on existing nuclear powerplants, a tax that would be dedicated to the development of solar electricity, particularly photovoltaics, and also to the development of a new generation of reactors that would be meltdown free. We have heard some discussion on this panel of reactors that may have those capabilities.

The billions of dollars per year that would be generated by such a tax would represent to us the most exciting commitment ever made by this country to a rational energy future. It would salvage something positive out of the Chernobyl disaster.

I believe that a joint program aimed at developing both cost-effective solar electricity and meltdown free reactors offers the best hope for both the solar and the nuclear industry.

Now why should the nuclear industry favor such a tax? Because the handwriting for them is on the wall. The only long-term hope for the industry, as some speakers have said today, is in meltdown free designs. I think the industry needs new critical allies and a new source of development funds.

Why should environmentalists and solar electricity advocates support a tax whose revenues would be shared with nuclear researchers? Because there is no way to develop a political concensus that will give solar electricity the edge it needs to compete with electricity from coal.

If current trends continue, the nuclear option will certainly die, but the victorious survivor will not be solar cells or solar collectors; it will be polluting coal plants, plants that cause respiratory illness, acid rain, and increased global temperatures.

Global warming from fossil fuel is such a serious environmental problem that environmentalists cannot afford to turn their backs on any possible option that might prove preferable.

If nuclear researchers can develop meltdown free designs, and if solar electricity fails to live up to its promise, I believe the environmentalists of the next century will change their opinion of nuclear power.

Now in conclusion, I hope that these remarks will spark discussion of positive responses that can be made to the Chernobyl accident, and the National Audubon Society is ready to work cooperatively with a wide range of groups to find concensus on energy policy.

Thank you, Senator.

[The prepared statement of Dr. Beyea follows:]

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# Responses to the Chernobyl Accident

Statement by

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before the

Senate Committee
on
Energy and Natural Resources

June 19,1986

AMERICANS COMMITTED TO CONSERVATION

As a nuclear physicist who has prepared many theoretical studies on reactor accidents,[1] I appreciate this opportunity to comment for the National Audubon Society on the relevance of the Chernobyl accident to the U.S. nuclear program.

The Chernobyl accident has many lessons to teach us:

Lesson 1: Reactor accidents, as predicted by theoretical computer models, are serious business.

At Chernobyl, millions of curies of radioiodine and radiocesium were released into the environment.[2] Thousands of cancers will likely result from the accident over the next 30 years.[3,4] The nightmarish vision, long feared by environmentalists, of a landscape contaminated by radioactivity has become a reality in the Ukraine. Russians in the Ukraine find themselves having to fear the very environment itself, the soil, fields, crops, gardens, even the beaches.

Lesson 2: Strong containments are valuable safety features.

We are fortunate in the United States that many of our reactors have large-volume containments that can hold enormous quantities of steam during an accident. Unfortunately, a significant fraction of U.S. reactors do not have strong containments. Reactors with ice-condenser safety systems will fail at very low pressures, and all 25 of the older, small-volume containments made by General Electric will quickly burst when assaulted by the copious amounts of steam and other gases that are likely to be produced in a core-melt situation.[5]

Furthermore, even large-volume U.S. containments are not guaranteed to survive a loss-of-coolant accident. There is considerable debate as to how high the internal pressures will rise during the course of an accident.[5] And human error, such as failure to close bypass valves, could render containments ineffective.

Consequently, it is incorrect for the nuclear industry to claim that the Chernobyl accident is irrelevant to the U.S. nuclear program.

It is worth noting that, prior to Chernobyl, the nuclear industry never made the charge that Russian reactors were unsafe. In fact, the trade association of the industry, the Atomic Industrial Forum, has always taken credit for the safety of Russian reactors in its world safety statistics.[6]

Lesson 3: Radioactivity from reactor accidents can travel enormous distances.

Computer models have been predicting for years that radioactivity in a bad accident will be carried across national boundaries.[7] Yet, no attempts to coordinate emergency planning between countries has taken place. The United States, for example, does not have agreements with either Mexico or Canada to deal with transborder radioactivity.

This lack of preparation for a real emergency is a perfect example of the decade-long paralysis that has gripped agencies responsible for protecting the public against accidents. When extensive planning measures have been the subject of public debate, regulating agencies have consistently folded in the face of fierce opposition from the nuclear industry and strong reaction from a public that often takes planning for a nuclear accident as an admission of guilt.

Consider the fact that before the Three Mile Island (TMI) accident, emergency planning zones in the United States did not extend beyond a few miles. And even TMI would not have brought us ten-mile zones without Congressional pressure.

Is ten miles enough? Chernobyl provides a resounding, "No." The Soviets evacuated out to eighteen miles. Chernobyl confirms the fact that the choice of a ten-mile emergency planning zone in the United States was based on politics, not public health considerations.

Lesson 4: The enthusiasm of nuclear engineers needs to be tempered by a strong regulatory process, one in which the voices of independent scientists and the public can be heard.

The Russian nuclear program demonstrates the dangers of a regulatory system in which believers in a technology are given free rein. In light of this lesson, it is distressing that the Chernobyl accident has not dampened the enthusiasm of the nuclear industry for restricting public involvement in the licensing process. Apparently, the industry is still promoting its restrictive version of licensing "reform." What such restrictive legislation will do is bring us closer to the regulatory system used by the Russians.

## POSSIBLE RESPONSES TO THE ACCIDENT

The National Audubon Society, like many other organizations, is trying to decide what recommendations to make in light of the Chernobyl accident. Although it is far too early for us to take a formal position on the implications of the accident for the U.S. nuclear program, I thought it would be useful to share with you some of the recommendations we are contemplating.

Note that some of the ideas put forward below are consistent with past positions taken in the Audubon Energy Plan[8]; some go beyond them.

Response # 1: Until the implications of the Chernobyl accident for the U.S. program can be thoroughly studied, reactors with weak containments should be turned off and put in cold shutdown.

The National Audubon Society will not recommend that all reactors be closed. To take such action on an an immediate basis would be to guarantee a large increase in the consumption of coal, which itself carries a drastic public health and environmental penalty.[9] The National Audubon Society favors a gradual phase-out of nuclear power--one that will occur naturally as units in existence today are decommissioned after the turn of the century.[8] Under such a policy, there will be time to gradually replace both coal and nuclear power with alternative sources of electricity and with conservation.

Nevertheless, despite our opposition to an immediate shutdown for all reactors, we are very concerned about the possible implications of the Chernobyl accident for small-volume containments. That is why we are considering supporting a moratorium on the operation of these types of reactors.

Fortunately, the United States today has an excess of electricity generating capacity in most parts of the country. Oil and natural gas prices are low. It will be a relatively inexpensive proposition to shut down small-volume containment reactors for a few months while the Chernobyl accident is being evaluated.

Should evaluations of the Chernobyl accident now under way indicate that the safety features of small-volume containments are indeed helpless in core-damage accidents, these reactors should be kept closed permanently. In such a situation, it may be necessary for the federal government to compensate the affected owners for the loss of their investment. After all, it was the federal government that licensed the designs. And without such compensation, it may be politically impossible to obtain the legislation or administrative action necessary to keep them shut permanently.

Response # 2: Emergency plans should be revised to include dose-reducing measures beyond ten miles.

Certainly, priority in planning should be given to evacuating people within ten miles of reactors, but that does not mean that everyone else should be treated, as is now the case, on an ad hoc basis. A staged evacuation is appropriate, with people within ten miles evacuating first.

There are other mitigation measures in addition to delayed evacuation that are appropriate for the population beyond ten miles.[10] For instance, plans for distribution of potassium iodide medicine to the post-ten-mile population could be implemented. Such medicine, if made available early enough, could significantly reduce the number of thyroid cancers that would occur in the population exposed to radioiodine.[10,11]

In addition to the steps suggested so far, arrangements should be made with Canada and Mexico to initiate and complete the difficult planning tasks that are associated with transborder transport of radioactivity. A consistent set of guidelines should be worked out for setting thresholds for food and land contamination.

Response # 3: All attempts to weaken public involvement in reactor licensing should be halted. Public participation should be made more meaningful by funding intervenors.

If there is any consensus lesson from the Chernobyl accident, it is that the nuclear industry needs criticism from a concerned public. Although the nuclear industry criticizes groups like the Union of Concerned Scientists (UCS), reactors are safer in the United States because UCS has been active over the years. But UCS gets involved with only a small number of interventions. Most interventions are started by local groups with little prior experience with nuclear power. The best way to ensure that these groups participate in an effective and meaningful way in the licensing process is to provide them with funds to pay technical witnesses.

Citizen groups are going to intervene regardless of whether or not there is NRC funding for them. But without adequate technical help to direct criticisms toward the real weaknesses of license applications, intervenors are going to continue to object to everything that seems the slightest bit suspicious, out of fear that someone is trying to pull the wool over their eyes. It is this fear by intervenors of being tricked, in my opinion, that has slowed down the regulatory process unnecessarily in the past.

Certainly, arming intervenors with technical experts is going to lead to discoveries that will halt license applications in some cases. But that's as it should be. On average, I believe intervenor funding will speed up the licensing process.

Response # 4: Impose a 1-cent per kilowatt-hour tax on existing nuclear power plants, one that will be dedicated to the development of solar electricity (particularly photovoltaics) and development of a new generation of reactors that will be "meltdown free."[12]

The billions of dollars per year generated by such a tax would represent the most exciting commitment ever made by this country to a rational energy future. It would salvage something positive out of the Chernobyl disaster.

A joint program, aimed at developing both cost-effective solar electricity and meltdown-free reactors, offers the best hope, in my view, for both the solar and the nuclear industry.

Why should the nuclear industry favor such a tax? Because the handwriting is on the wall. There are not going to be any new orders for nuclear plants of the current generation, no matter how many nuclear licensing bills are passed. The only long-term hope for the industry is in meltdown-free designs. But the industry no longer has the political muscle to gain the federal funds that will be needed to develop such designs. The industry needs new political allies and a new source of funds.

Why should environmentalists and solar electricity advocates support a tax whose revenues would be shared with nuclear researchers? Because there is no other way to develop a political consensus that will give solar electricity the edge it needs to compete with electricity from coal. If current trends continue, the nuclear option will certainly die, but the victorious survivor will not be solar cells or solar collectors. It will be polluting coal plants that cause respiratory illness, acid rain, and increased global temperatures.

Global warming from fossil fuel carbon dioxide is such a serious environmental problem that environmentalists cannot afford to turn their backs on any possible option that might prove preferable. If nuclear researchers can develop the meltdown-free designs that many scientists believe are possible, and if solar electricity fails to live up to its promise, then environmentalists of the next century will no doubt change their opinion of nuclear power.

## CONCLUDING REMARKS

Hopefully, the preceding remarks will spark discussion of positive responses that can be made to the Chernobyl accident. The National Audubon Society is ready to work cooperatively with a wide range of groups to help our country break out of the dead end in energy policy in which we now seem to be trapped. It is time to find consensus on energy policy.

## Footnotes and References

1) Most of these studies on reactor accidents were prepared while I was a member of the research staff at the Center for Energy and Environmental studies at Princeton University.

2) Although estimates made by western experts are higher than numbers quoted by the Soviets [New York Times, June 12, 1986], all estimates imply that millions of curies were released during the accident.

3) A preliminary (and conservative) estimate of the number of Chernobyl-related cancers that will eventually result in Europe from radioactive Cesium-137 deposited on the ground has been made by Frank von Hippel of Princeton University and Thomas B. Cochran of the Natural Resources Defense Council. ["Chernobyl--The Long-Term Health Consequences," June 11, 1986, Draft. The final version of this article is to be published in the September 1986 issue of the Bulletin of the Atomic Scientists.]

Starting from meteorological dispersion maps prepared by Lawrence Livermore Laboratory (Ref. 4), von Hippel and Cochran obtained a range of 3200 to 9600 cancers. Of course, all estimates of this type are preliminary and will no doubt change as more information about fall-out patterns is published and analyzed.

4) Joseph B. Knox and Marvin B. Dickerson ("technical contacts"), "ARAC Preliminary Dose Estimates for Chernobyl Reactor Accident," Lawrence Livermore National Laboratory, May 7, 1986.

5) Jan Beyea and Frank von Hippel, "Containment of a Reactor Meltdown," Bulletin of the Atomic Scientists, 38, August/September 1982, p. 52.

6) See past issues of Nuclear INFO, 7101 Wisconsin Avenue, Bethesda, MD 20814-4891.

7) That radioactivity from reactor accidents can travel across national boundaries has been recognized ever since a 1957 accident in Windscale England released 20,000 curies of radioiodine, remnants of which were tracked far over Europe. [N.G. Stewart, R.N. Crooks, "Long-Range Travel of the Radioactive Cloud from the Accident at Windscale," Nature, 4636, p. 627 (1958).]

Since 1957, the notion has appeared in numerous technical and policy-related papers. For instance, the puff trajectory model, MESOS, was initiated in 1976 to simulate the atmospheric transport and dispersal of radionuclides over distances of several hundred kilometers or more. [H.M. ApSimon, A.J.H. Goddard, J. Wrigley, "Long-Range Atmospheric Dispersion of Radioisotopes-I. The MESOS Model," Atmospheric Environment 19, pp. 99-111 (1983).] The authors state that such calculations are relevant to planning for the possible transfrontier consequences of a nuclear accident in a neighboring country."

In a 1978 study prepared for the Swedish Energy Commission, I pointed out that long-term health consequences from an accident in Sweden would appear in other countries. ["A Study of Some of the Consequences of Hypothetical Reactor Accidents at Barseback," Swedish Energy Commission, Stockholm, DS I 1978:5, 1978.] Similarly, in a 1980 report to the U.S. Council on Environmental Quality, I stated that "emergency planning......may require cooperation between different states and, in some cases, cooperation with Canada or Mexico."

8) The Audubon Energy Plan, National Audubon Society, 1984.

9) 50,000 respiratory-related deaths per year have been correlated with sulphur air pollution, much of which comes from coal-burning electricity plants. Even when coal plants are equipped with scrubbers, some sulphur escapes. [For references to sulphur air pollution and mortality, see, Jan Beyea, G. Steve Jordan, "Implications for Mortality of Weakening the Clean Air Act," National Audubon Society, EPAD Report 18, May 1982.]

As is well known, coal-burning plants are major contributors to acid rain. Less appreciated is the fact that use of coal adds significant amounts of carbon dioxide to the atmosphere, threatening to change the climate of the entire planet.

10) Jan Beyea, "Emergency Planning for Reactor Accidents," Bulletin of the Atomic Scientists, 36, December 1980, p. 40.

11) Frank von Hippel, "The NRC and Thyroid Protection--One Excuse After Another," Bulletin of the Atomic Scientists, October 1980, p. 44.

12) See for instance, A.M. Weinberg, I Spiewak, "Inherently Safe Reactors and a Second Nuclear Era," Science, 224, 1398-1402 (1984). See also, J. L. Dooley, R. Philip Hammond, "Build Nuclear Plants that Don't Need Evacuation Plans," Wall Street Journal, June 12, 1986.

THE BULLETIN
OF THE ATOMIC SCIENTISTS

# Containment of a Reactor Meltdown

Jan Beyea and Frank vonHippel

**Jan Beyea** and **Frank von Hippel**

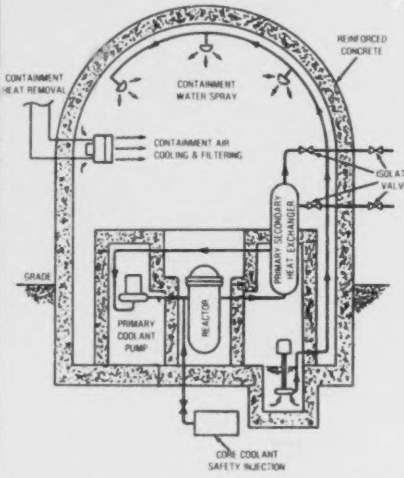
# Containment of a reactor meltdown

Any good scientist or engineer believes implicitly in Murphy's law: "If something can go wrong, sooner or later it will go wrong." The U.S. Atomic Energy Commission, which until 1975 had the responsibility for ensuring the safety of U.S. civilian power reactors, had many good scientists and engineers involved in its work. And during its history it repeatedly considered the consequences of all the safety systems in a nuclear reactor failing, the fuel melting and the volatile radioactive isotopes in the fuel being released to the atmosphere.

The answer which came back from major studies in 1957 [1], 1965 [2] and 1975 [3] was always that the consequences could be very serious indeed. This finding underlined the importance of preventing nuclear reactor meltdown accidents. As a result, the Atomic Energy Commission and the Nuclear Regulatory Commission (NRC), its successor in the area of nuclear safety regulation since 1975, required so many redundant safety systems on nuclear power plants that both nuclear regulators and the nuclear industry became convinced that the likelihood of a reactor meltdown accident had been reduced to a negligible level.

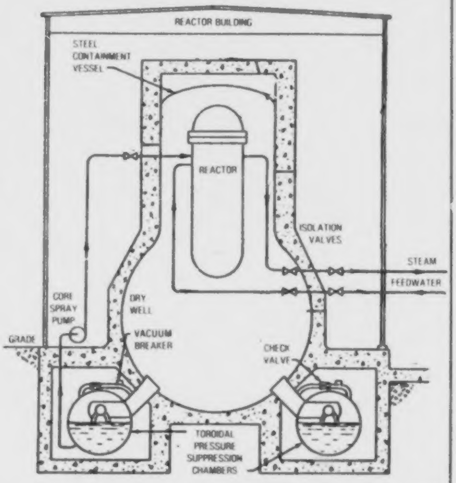
The massive failure of safety systems and the associated confusion which has occurred repeatedly at nu-

Figure 1
LARGE VOLUME PRESSURIZED WATER CONTAINMENT


REINFORCED CONCRETE
CONTAINMENT HEAT REMOVAL
CONTAINMENT WATER SPRAY
CONTAINMENT AIR COOLING & FILTERING
ISOLATION VALVES
PRIMARY SECONDARY HEAT EXCHANGER
GRADE
PRIMARY COOLANT PUMP
REACTOR
CORE COOLANT SAFETY INJECTION

Because of its large volume (about 60,000 cubic meters), this containment can hold all of the steam released in the first minutes of a loss of coolant accident. Subsequently steam pressure should be reduced by the containment water sprays.

Figure 2
SMALL VOLUME BOILING WATER CONTAINMENT


REACTOR BUILDING
STEEL CONTAINMENT VESSEL
REACTOR
ISOLATION VALVES
STEAM
FEEDWATER
CORE SPRAY PUMP
DRY WELL
VACUUM BREAKER
GRADE
CHECK VALVE
TOROIDAL PRESSURE SUPPRESSION CHAMBERS

The combined volume of the dry well and the connected free space over the pressure suppression pool is only one eigth that of the containment shown in Figure 1. Steam from the dry well bubbles through the water in the pressure suppression chamber and is condensed. This could prevent overpressurization by steam but not by other noncondensable gases such as hydrogen and carbon dioxide.

*Source*: T.J. Thompson and J.G. Beckerly, *The Technology of Nuclear Reactor Safety*, vol. 2, chap. 21 (Cambridge, Mass.: MIT Press, 1973).

**So many tens of billions of dollars had been invested in plants which were already operating or in an advanced stage of construction that nuclear safety authorities were unwilling to question the basic safety design features of nuclear power plants.**

clear power plants since 1975—with serious damage resulting at Brown's Ferry in 1975 [4] and Three Mile Island in 1979 [5]—have, however, thrown this confidence into question. Our purpose here, therefore, is to draw wider attention to the possibilities for increased public protection offered by the last barrier between the radioactivity released from a molten core and the outside world: the reactor containment building.

*The containment.* Reactor containment buildings are both massive and well-equipped (Figures 1 and 2). Most are designed to withstand internal pressures of three to four atmospheres and may maintain their integrity at more than six atmospheres internal pressure. They also have water sprays, water pools or compartments full of ice—whose purpose is to reduce pressures by removing steam from the containment atmosphere.

Reactor containment buildings today are not designed to contain a reactor core meltdown accident, however. Their "design basis accident" is a loss-of-coolant accident in which large amounts of volatile radioisotopes are released from a temporarily overheated core, but in which the uncontrolled release of energy from the core into the containment atmosphere is terminated by a flood of emergency core cooling water before an actual meltdown occurs. This is essentially what happened during the accident at Three Mile Island although, due to various errors, the core remained only partially cooled for a period of hours.

*The threat of overpressurization.* If for any reason the emergency core cooling system were not effective and a core meltdown occurred, the buildup of internal pressure in a sealed reactor containment building could rupture it within a matter of hours. The threat would come from steam, hydrogen and other gases.

For an extended period of time after a reactor shutdown, the radioactive fission products in a reactor core generate heat at a rate great enough to turn hundreds of metric tons of water into steam per day (Figure 3). It would take only about 300 metric tons of steam to increase the pressure inside even a large (60,000 cubic meter volume) Three Mile Island type of containment building by about ten atmospheres. It is apparent, therefore, that unless the containment cooling system operates reliably and effectively to keep this steam pressure from building up, the containment will quickly be overpressured by steam alone [6].

Hydrogen is another potential contributor to the pressurization of the containment. It is produced when water or steam comes into contact with a metal which binds oxygen so strongly that the metal can take oxygen away from water molecules. Because it absorbs relatively few neutrons, one such metal, zirconium, is the structural material of choice used in the cores of water cooled reactors. Zirconium starts reacting rapidly with steam at temperatures above 1,100°C. About one half the zirconium in the core of Three Mile Island Unit No. 1 was oxidized during the accident there [7].

For a small volume (boiling water reactor type) containment, the mere pressure developed by the amount of hydrogen generated at Three Mile Island would have been enough to raise the containment pressure by one to three atmospheres.

For a large volume containment, the principal hazard associated with the hydrogen would be fire or explosion, and in fact the hydrogen did burn at Three Mile Island. Fortunately, however, the initial pressure in the containment building was such that the containment was able to withstand the resulting pressure increase of about two atmospheres. Some existing reactor containments would not have withstood the pressure rise associated with the burning of this much hydrogen—even given an initially low pressure.

In small boiling water reactor containments the probability of a hydrogen fire is eliminated by "inerting" the containment with an atmosphere of pure nitrogen. This is not done, however, in ice condenser containments which are designed to withstand much lower internal pressures than most other containments. On September 8, 1980, during a final review of the design of Sequoyah Nuclear Power Plants, Units 1 and 2 (which are equipped with ice condenser containments) the NRC's watchdog, the Advisory Committee on Reactor Safeguards, pointed out in a letter to the Commission that: "For events involving more than 30 percent oxidation of the zirconium, hydrogen control measures may be necessary to avoid containment failure."

The remaining threat to containment integrity from overpressurization during a core meltdown accident would arise from the carbon dioxide and carbon monoxide liberated as the molten core melted its way down through the concrete basemat of the reactor building [8; 9].

This listing is sufficient to suggest why one of today's small volume reactor containment buildings would probably rupture during a core meltdown accident and why there is a significant, although less certain, probability of failure for a large volume pressurized water reactor type containment [3].

*The regulatory response.* The situation we have just described was first explored by an Atomic Energy Commission advisory committee in 1966 when the AEC was just beginning to license the construction of today's large commercial power reactors. The advisory committee recommended in its report, however, that the Commission should undertake only "a small-scale, tempered effort on [the]

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problems . . . associated with systems whose objective is to cope with the consequences of core meltdown. . . ." The committee did not recommend a crash program on the development of better containments because it felt that "to produce effective designs, if indeed feasible, might require both considerable fundamental research and practical engineering application." Instead, the committee advised the Commission that "for the time being, assurance can be placed on existing types of reactor safeguards, principally emergency core-cooling" [10].

The Commission accepted this advice and went ahead with the licensing of containment buildings whose integrity depended upon the successful functioning of emergency core cooling systems. A small amount of research was conducted for a time into the possibility of improved containment concepts. As the Commission certified time after time that existing containment designs were adequately safe, however, this research was phased out.

Periodically, the issue of improved containment designs was brought up by outsiders. For example, in 1975 the American Physical Society Study Group on Light Water Reactor Safety recommended that "more emphasis should be placed on seeking improvement in containment methods and technology" [11]. By that time, however, so many tens of billions of dollars had been invested in nuclear power plants which were already operating or in an advanced stage of construction, that the nuclear safety authorities were unwilling to question the basic safety design features of nuclear power plants.

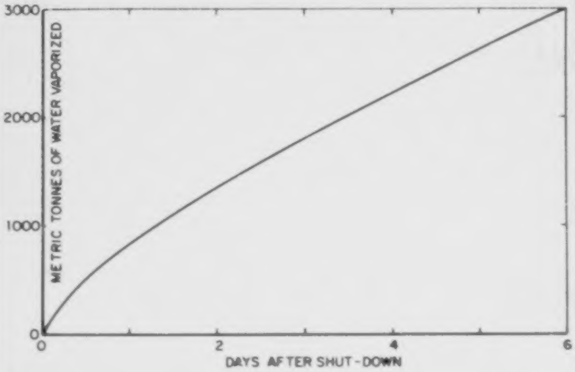
This attitude was expressed in a memorandum written on September 25, 1972 by Joseph Hendrie, then Deputy Director for Technical Review of the Atomic Energy Commission. Hendrie was responding to the suggestion by a senior member of the Commission staff, Steven Hanauer, that because of the safety disadvantages of small volume containment buildings such as the General Electric boiling water reactor pressure suppression containment shown in Figure 2 and the ice condensor pressure suppression containment design being proposed at the time by Westinghouse, "I recommend that the AEC [Atomic Energy Commission] adopt a policy of discouraging further use of pressure suppression containments." Hendrie's response is reproduced in full below:

> "With regard to the attached, Steve's idea to ban pressure suppression containment schemes is an attractive one in some ways. Dry containments have the notable advantage of brute simplicity in dealing with a primary blowdown, and are thereby free of the perils of bypass leakage.
>
> However, the acceptance of pressure suppression containment concepts by all elements of the nuclear field, including Regulatory and the ACRS [Advisory Committee on Reactor Safeguards], is firmly imbedded in the conventional wisdom. Reversal of this hallowed policy, particularly at this time, could well be the end of nuclear power. It would throw into question the operation of licensed plants, would make unlicensable the GE and Westinghouse ice condensor plants now in review, and would generally create more turmoil than I can stand."

This memorandum became public as a result of a Freedom of Information Act suit by the Union of Concerned Scientists reinforced by Congressional pressure following Hendrie's appoint-

Figure 3

POTENTIAL STEAM PRODUCTION BY RADIOACTIVE AFTER-HEAT (1000 MEGAWATT REACTOR)



The figure shows the cumulative amount of water which would be evaporated by the radioactive after-heat generated after shut-down by the core of a typical modern 1,000-megawatt light water reactor. In the absence of heat removal from the containment, the steam pressure so generated would threaten the containment integrity within hours.

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ment to the chairmanship of the Nuclear Regulatory Commission in 1977.

*Filtered vents.* As more and more nuclear power plants went into operation, the attention of those who wished to improve reactor containment designs turned to safety systems which could be "retrofitted" onto existing plants and to one specific idea in particular. This was a "filtered vent" system which could relieve the pressures inside a dangerously pressurized containment building by releasing some of its radioactive gases to the atmosphere through a large filter system. There the most dangerous radioactive species would be trapped before the filtered containment gases were allowed to escape. It would be relatively easy to add such a system onto an already completed containment building because the filter system could be installed in a separate building outside the existing containment building and connected to it through a large valve and underground pipe (Figure 4 [12]).

The installed cost of one of these systems has been estimated to be between $1 million and $20 million per reactor, an amount which is small in comparison with the more than $1 billion total cost of a modern nuclear power plant [13].

Despite these attractive aspects of the vented containment concept, the Nuclear Regulatory Commission proceeded to investigate it extremely slowly and cautiously. While the Commission's slowness can only be deplored, its caution is appropriate: prescriptions for nuclear safety, like those for drugs, should be both safe and effective and the staff has concerns in both areas.

In the area of effectiveness the staff's concerns focus on the possibility that in certain accident sequences the pressure buildup inside the containment might be so rapid that no exhaust system of realistic size could release gas fast enough to save it. The pressure rise associated with a hydrogen fire could, for example, be very rapid. Rapid increases in steam pressure could also occur within the containment of a pressurized water reactor as a result of sudden contacts between large amounts of molten core and large amounts of water.

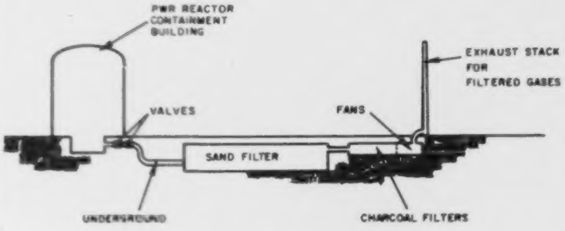
According to current ideas, a melting reactor core would not drip away. Instead, it is believed more likely that a large fraction of the core would suddenly collapse and fall into the water remaining at the bottom of the reactor pressure vessel. In the past there has been concern in the reactor safety community about such an event resulting in a "steam explosion" violent enough to propel the top of the reactor vessel through the shell of a containment building. This concern has been downgraded in most recent studies but inside even a large containment building a rapid increase in pressure of about one atmosphere could occur.

In some scenarios, where the primary pressure system around the reactor core and its attached piping remain intact until the core actually melts through the pressure vessel, the meltthrough would relieve the steam pressure in the primary system, with the result that certain water in the system would be mobilized and pour into the pressure vessel on top of the molten core. This could cause a rapid pressure rise of one to three atmospheres. And finally, after melting through the pressure vessel, the molten core could, once again, fall into a pool of water collected in the cavity below the vessel. Another rapid increase in pressure could then result [9, 1].

There appear to be strategies that can reduce the threat of containment failures resulting from such pressure increases if in fact further analysis should establish this threat as a serious one: Indeed, the Nuclear Regulatory Commission is already beginning to require hydrogen "igniters" capable of burning any accumulating hydrogen in stages before concentrations can build to levels where a single fire will be intense enough to endanger the containment. The magnitude of some of the steam pressure rises associated with core meltdowns in pressurized water reactors could also be reduced by relieving the pressure in the primary system and flooding the

Figure 4[12]

GENERAL ARRANGEMENT OF A PWR FILTERED VENT SYSTEM



If the pressure inside the containment climbed to dangerous levels, the isolation valves could be opened and some of the containment gas released through sand and activated charcoal filters.

**As more and more nuclear power plants went into operation, attention turned to safety systems which could be retrofitted onto existing plants. . . .**

containment building with water to a level which covers the pressure vessel when a meltdown appears inevitable. And, as we have seen, a filtered vent would make possible still another strategy: early venting so as to reduce the pressure base on which any subsequent sudden pressure increases would build.

The possibility of early venting is two-edged, however, because it requires a judgment that nothing else can be done to prevent a major release of radioactivity. That judgment might be wrong or the filtered venting system might even operate accidentally. The resulting releases would be dominated by the non-filterable radioactive noble gases which would contribute about one-thousandth of the cumulative radiation dose from an uncontained meltdown accident. The Commission's safety concern about filtered venting, therefore, focuses on the fact that a filtered vent system, while offering some protection against large releases of radioactivity to the atmosphere would also increase by an uncertain amount the frequency of public exposure to very much smaller releases.

This concern is akin to the one about automobile seat belts – that by slowing a passenger's escape from a vehicle in some accident situations, a seat belt could contribute to rather than prevent a death. But seat belts, as we know from statistics, save vastly more lives than they endanger. In the case of reactor core meltdown accidents we (fortunately) have no statistics yet. The Commission will, therefore, have to make a careful judgment. It seems likely that the final conclusion will be that, for a well-designed system, the reduction in the risks of large releases will greatly exceed the increased risk of small releases. At the current level of effort, however, it will take many years before thorough safety analyses have been concluded on each major type of reactor containment; and then more years may be taken up in conducting specific safety analyses on each plant chosen as a candidate for retrofit.

*The industry response.* In response to the Three Mile Island accident, the U.S. nuclear industry could have put

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**An area the size of Connecticut**

Among nuclear power opponents one of the most widely used characterizations of the hazard from reactor accidents is based on a quote from the files of the long-suppressed 1965 Atomic Energy Commission study on reactor accident consequences: "The possible size of such a disaster might be equal to that of the state of Pennsylvania"[2].

What exactly would happen over this area?

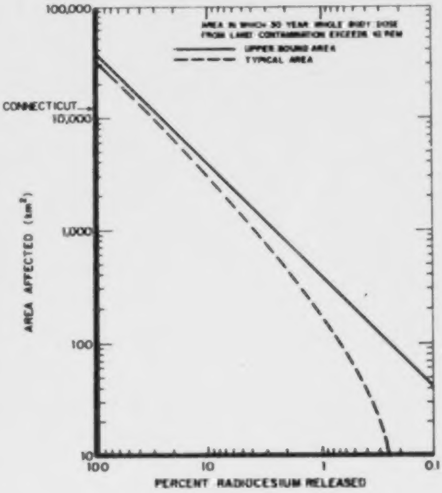
The study found – as have many studies since [3, 11, 20] – that the most widespread danger from a reactor accident would be thyroid damage from the ingestion of radioactive iodine. Milk might be contaminated with radioiodine above the protective action limits specified by the Federal Radiation Council over "areas which would range from 10,000 to 100,000 square kilometers" [2]. The area of Pennsylvania is 115,000 square kilometers; hence the comparison.

The problem of milk contamination by radioiodines appears to us to be a relatively manageable one [21], so we focus instead on two potential consequences of reactor core meltdown accidents which are less manageable than milk contamination and could also affect huge areas. These are the hazards of long-term contamination of land and property by radioactive cesium; and thyroid damage resulting from the inhalation of radioactive iodine-131.

For land contamination we have set the threshold at a standard level corresponding, in the absence of decontamination, to a cumulative whole-body dose from penetrating external gamma radiation of 10 rem to any resident population over the first 30 years following the accident. (The duration of land contamination will be dominated by 30-year half-life cesium-137.) This 10-rem dose would be approximately three times higher than the average whole-body dose from natural background radiation over the same period and might cause on the order of one extra cancer death among every 1,000 people exposed at that level [22].

In the case of thyroid irradiation we have chosen a

Figure 5



**. . . a filtered vent system could relieve the pressures inside a dangerously pressurized containment building by releasing some of its radioactive gases through a large filter system.**

its own resources into investigating the possibilities for the reduction of radioactive releases following core-melt accidents. Unfortunately, it did not. Instead, the industry mounted a concerted campaign to convince both the public and government that, even in case of containment failure, the resulting release of radioactivity to the atmosphere would be much less than has always been thought. In particular, the electrical utilities' Electric Power Research Institute published a study which concluded, in effect, that improved containments were not necessary [14].

The Institute report claimed that, even in the event of a core meltdown accident and a containment failure, "due to the solubility of the volatile fission product compounds and the aerosol behavior mechanisms, the off-site dispersion of radioactive materials (other than gases) following a major LWR [light water reactor] accident will be small." The electric utilities' public relations departments and the nuclear industry press sprang into action and advertised these claims with great fanfare, noting that "If findings like these are verified . . . it would go far toward deflating the doomsday predictions of anti-nuclear groups" [15]. The Nuclear Regulatory Commission, aside from a few staff comments in the trade press, expressed no public reservations concerning the significance of these claims, which tended to give them further credibility.

The Commission did, however, authorize an effort to examine the Institute's claims as a collaborative enterprise between Commission staff members and technical experts at three major national laboratories. In March 1981 this team stated in a draft report:

> "The results of this study do not support the contention that the predicted consequences of the risk dominant accidents have been overpredicted by orders of magnitude in past studies. For example, the analysis in this report indicates that . . . 10% to 50% of the core inventory of iodine could be released to the environment" [16].

Under pressure from the industry, the

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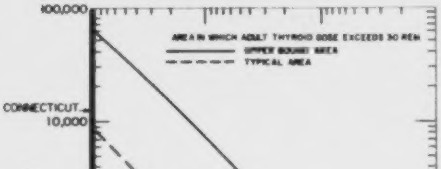
threshold dose from inhalation of 30 rem for adults. The Environmental Protection Agency's guideline threshold dose to the thyroid for mandatory evacuation is 25 rem [23]. The dose to the thyroids of exposed children in the same area might exceed 150 rem [24]. For an X-ray dose of 150 rem to a child's thyroid, the probability of subsequent thyroid surgery has been found to be on the order of a few percent [25].

Figure 6



There has been less follow-up on the consequences per rem to the thyroid of internal beta-radiation emitted by iodine-131. The U.S. Food and Drug Administration, therefore, assumes that iodine-131 irradiation is as damaging to the thyroid per rem as X-ray radiation [26].

Figures 5 and 6 show, as a function of the percentage released into the atmosphere of the inventories of radioactive cesium and iodine from the core of a modern commercial power reactor, "typical" and realistic upper bound areas over which the long-term doses from ground contamination and the thyroid inhalation doses would exceed the thresholds specified above [27]. The upper bound curves in the figures are about the highest which can be obtained for reasonable choices of parameters using the standard simplified model for atmospheric dispersion. We show no lower limit for the area which could be affected because it could be essentially zero. A heavy rain could, for example, scrub the radioactive aerosols from the air soon after they were released from the containment.

For an uncontained meltdown, most studies predict that from 10 to 90 percent of the radioactive iodines and cesiums in the core could be released [3, 16]. It is apparent from figures 5 and 6 that the area affected by such releases with doses above the specified thresholds could be on the order of 10,000 square kilometers. Even if this is closer to the area of the state of Connecticut than Pennsylvania, it is still a very substantial area. It is also apparent that the areas at risk could, for example, be decreased by about one hundredfold if reactor containment systems could be made effective enough to reduce any releases to less than one percent of the core inventories [28]. ☐

**The industry is concerned that accident mitigation techniques, such as off-site preparations for emergencies and retrofitting with filtered venting systems, could be interpreted as tacit admissions that serious accidents can happen.**

Commission subsequently rewrote the summary language so that it no longer appeared to be a rebuttal to the Electrical Power Research Institute report. Nevertheless, the technical conclusions remained the same.

*The role of public pressure.* There are by now many examples of public pressure being required to offset the paralyzing effect of industry opposition to nuclear safety initiatives – especially when the purpose of the initiatives is to mitigate the consequences of nuclear reactor accidents. The industry is apparently concerned that the adoption of accident mitigation techniques, such as off-site preparations for emergencies and retrofitting containment buildings with filtered venting systems, could be interpreted by the public as tacit admissions that serious accidents can happen.

It was only after Congressional pressure developed for improved emergency planning in the aftermath of Three Mile Island, for example, that the Commission converted the recommendations of a Nuclear Regulatory Commission/Environmental Protection Agency task force report into Commission policy and extended the emergency planning zone for accidents out to 16 kilometers from reactors.

In Sweden, it appears that the political pressure of that country's debate over nuclear power may have already forced a decision in the case of filtered venting. Prior to that country's March 1980 referendum on the future of nuclear power the pro-nuclear side was eager to support every safety measure proposed by a special Swedish government committee of enquiry, created after the Three Mile Island accident. Filtered venting was one measure recommended by this committee. After the referendum, the Swedish government, noting that subsequent studies had failed to uncover any basis for a reconsideration of this decision, indicated in a parliamentary bill that it would move forward to implement filtered venting starting with the Barsebäck reactor located just 20 kilometers across the sound from Copenhagen [17].

Without the pressure of a political referendum, it is doubtful that progress on filtered venting would have been any faster in Sweden than it has been in the United States.

Unfortunately, there are no comparable political events on the horizon in the United States. It is possible, therefore, that it will take an accident more serious than Three Mile Island to overcome the inertia that is holding back further development of containment improvements in this country. If a large release of radioactivity occurs in such an accident, the U.S. nuclear industry may well follow the example of its Swedish counterpart and endorse containment improvements in an attempt to salvage a future for nuclear power in the United States.

The prognosis for our society will be bleak, however, if we protect ourselves only after experiencing every variety of disaster. It is, therefore, to be hoped that the Commission and its watchdogs will press ahead with work on accident consequence mitigation strategies from the "study" stage to the decision stage.

The Commission received exactly this recommendation from its Three Mile Island "Lessons Learned Task Force" in October 1979:

> "The Task Force recommends . . . that a notice of intent to conduct rulemaking be issued to solicit comments on the issues and specific facts relating to the consideration of controlled, filtered venting for core-melt accidents in nuclear power plant design and that a decision on whether and how to proceed with this specific requirement be made within one year of the notice" [18].

The Commission, however, did not commit the necessary resources. Now, almost three years later, it is further away from such a decision than it was then.

The Commission could also be pressured into adopting the recommendation made to it in a September 10, 1980 letter from its Advisory Committee on Reactor Safeguards: that it proceed without further delay to require utilities to do design and risk reduction studies with regard to the installation of filtered vent systems on their nuclear power plants [19].

Of course the filtered vent strategy should not be pursued to the exclusion of other containment improvement strategies which may also prove useful. We have focused on the vented containment concept here because it is specific evidence for our more general contention that there is a great potential for enhancing the capabilities of reactor containment buildings to retain the radioactivity from accidents which might otherwise contaminate an area "the size of Connecticut." [See box.] ☐

1. U.S. Atomic Energy Commission, *Theoretical Possibilities and Consequences of Major Accidents in Large Nuclear Power Plants*, WASH-740 (1975).

2. U.S. Atomic Energy Commission, *Documents Relating to the Re-examination of WASH-740*. Approximately 200 unpublished documents, dating from 1964 to 1966, were made available to the public in the Commission's public document room in 1973 as a result of suits and threats of suits under the Freedom of Information Act. See also David Burnham, "A.E.C. Files Show Effort to Conceal Safety Perils," N.Y. Times (Nov. 11, 1974).

3. U.S. Nuclear Regulatory Commission, *Reactor Safety Study* (Washington, D.C., WASH-1400 or NUREG-75/014, 1975). Initiated by the Atomic Energy Commission, this study was published in its final form by the Nuclear Regulatory Commission.

4. U.S. Congress, Joint Committee on Atomic Energy Hearings, "Brown's Ferry Nu-

**It is possible that it will take an accident more serious than Three Mile Island to overcome the inertia that is holding back further development of containment improvements.**

clear Plant Fire" (Sept. 16, 1975); Daniel F. Ford, Henry W. Kendall, Lawrence S. Tye, *Brown's Ferry: The Regulatory Failure* (Cambridge, Mass.: Union of Concerned Scientists, 1976).

**5.** *Report of the President's Commission on the Accident at Three Mile Island* (1979).

**6.** We have assumed containment atmosphere temperatures of about 150 degrees Centigrade in these calculations.

The free volume in a containment typical of those used in most operating U.S. boiling water reactors is about 7,900 cubic meters. The *effective* free volume of boiling water reactor containments may be less than half of their nominal volumes, however, since the volume over the pressure suppression pool is connected to that of the "dry well" by what amounts to a one-way valve. Therefore, it would be possible, in principle, for steam to drive the "noncondensable" gases into the 40 percent of the total free volume over the pressure suppression pool, leaving the pressure in that chamber at a much higher level than in the dry well surrounding the reactor vessel after the steam condensed. (See Figure 2 for a representation of these chambers in a boiling water containment. The range of pressures cited in the text allows for this possibility.)

**7.** In the Three Mile Island accident an estimated 44 to 63 percent of the 22,600 kilograms of zirconium in the core were oxidized. See *Report of the President's Commission on the Accident at Three Mile Island*, (staff reports), II, p. 14.

**8.** For a "high-carbonate concrete" having 80 weight percent $CaCO_3$ and an initial radius of the core debris on the reactor cavity floor of 3.05 meters the "WECHSL" code predicts that the core will have penetrated 80 centimeters into the concrete 10 hours after it has landed on the surface and will have thereby released 27 metric tonnes of $CO_2$, 13 of CO, 9 of $H_2O$, and 140 kilograms of $H_2$. The carbon monoxide and hydrogen result from reactions between $CO_2$ and $H_2O$ and hot metals (steel and zirconium) in the melt. The oxides of carbon would add about two-thirds of an atmosphere to the pressurization of a small containment. A "medium-carbonate" concrete is characterized as having 46 weight percent $CaCO_3$ and therefore presumably would release about half as much $CO_2$ plus CO. Another code, "INTER," predicts about twice as much gas evolved as WECHSL. See also W.B. Murfin, I., p. 5. 18.

**9.** W.B. Murfin, *Report of the Zion/Indian Point Study* (U.S. NRC NUREG-CR 1409-1413, 1980), Summary, p. 49.

**10.** Report of the Task Force on Power Emergency Cooling, "Emergency Core Cooling," U.S. AEC, TID-24226 (1966), p.9.

**11.** "Report to the APS by the Study Group on Light Water Reactor Safety," *Review of Modern Physics 47*, Sup. No. 1 (1975), p. S7.

**12.** B. Gosset, H.M. Simpson, L. Cave, C.K. Chan, D. Okrent and I. Catton, *Post-Accident Filtration as a Means of Improving Containment Effectiveness* (University of California at Los Angeles, UCLA-ENG-7775, 1977). The principal radioisotopes which would not be removed by such a filtered vent system would be the noble gases: radioactive krypton and xenon.

**13.** D. Carlson and J. Hickman, *A Value-Impact Assessment of Alternate Containment Concepts* (Washington, D.C.: Nuclear Regulatory Commission, NUREG-CR-0165, 1978). The Murfin Report estimates a $20 million price tag. More elaborate versions would cost more.

**14.** M. Levenson and F. Rahn (Electric Power Research Institute), "Realistic Estimates of the Consequences of Nuclear Accidents," paper presented at the International Meeting of the American Nuclear Society, Washington, D.C. (Nov. 20, 1980).

**15.** John O'Neill, "Scientists Say NRC Greatly Overestimates Accident Risks," *Nuclear Industry* (Dec. 1980), p. 27.

**16.** U.S. Nuclear Regulatory Commission, *Technical Bases for Estimating Fission Product Behavior During LWR Accidents*, NUREG-0722, draft (March 6, 1981; final, June 1981). The basic points in the NRC experts' review were immediately apparent to knowledgeable readers of the Institute report. See Frank von Hippel, an invited briefing to the NRC as recorded in the transcript, "NRC Meeting on Iodine Release from Accidents and Estimates of Consequences," (Nov. 18, 1980), pp. 38-61. For accidents in which the damage is sufficient to open large pathways from the core to the containment, there will not be sufficient water available to trap the radioactive materials of concern, nor will the pathway be so tortuous that a significant amount will stick to surfaces before reaching the containment atmosphere. Similarly, if the containment fails early enough, there will be insufficient time for aerosols to settle to the reactor building floor. These three mechanisms are the basis for the claims made in the Electric Power Research Institute report.

**17.** Government bill to Swedish Parliament, 1980/81:90. It is expected that the Barseback reactor would be equipped with a filtered vent system by 1985.

**18.** Nuclear Regulatory Commission, *TMI-2 Lessons Learned Task Force Final Report* (Washington, D.C.; NUREG-0585, 1979), pp. 3-5.

**19.** Advisory Committee for Reactor Safeguards letter to the NRC on "Additional ACRS comments on Hydrogen Control and Improvement of Containment Capability" (Sept. 8, 1980). The point was reiterated in a Feb. 10, 1981 ACRS letter on "ACRS Report on Requirements for Near-Term Construction Permits and Manufacturing Licenses."

**20.** Jan Beyea, "Some Long-Term Consequences of Hypothetical Major Releases of Radioactivity to the Atmosphere from Three Mile Island," a report to the President's Council on Environmental Quality (Princeton University, Center for Energy and Environmental Studies Report #109, 1980).

**21.** The longest lived radioiodine of concern for reactor accidents is eight-day half-life iodine-131, of which only one-thousandth the original will remain after eight weeks. The area of land contamination will, therefore, have decreased after eight weeks by orders of magnitude from its original size. During the period of contamination it would be quite straightforward to arrange where necessary that dairy cattle be shifted from pasture to relatively uncontaminated stored feed, and to divert any contaminated milk to the production of powdered milk, cheese, etc., which could be stored until its radioactive contamination had decayed to negligible levels.

**22.** U.N. Scientific Committee on the Effects of Atomic Radiation, *Sources and Effects of Ionizing Radiation* (New York: United Nations, 1977), p. 414; U.S. National Academy of Sciences, Committee on the Biological Effects of Ionizing Radiation, *The Effects on Population of Exposure to Low Levels of Ionizing Radiation* (Washington, D.C., 1980); Eliot Marshall, "New A-Bomb Data Shown to Radiation Experts," *Science 212* (1981), p. 1,364 and the related letters in *Science 213* (1981), pp. 6, 8, 392, 602, 604.

**23.** U.S. Environmental Protection Agency, *Manual of Protection Action Guides and Protective Actions for Nuclear Incidents* (Washington, D.C.: EPA-520/1-75-001, 1975), Table 5.2.

**24.** U.S. Environmental Protection Agency, *Environmental Analysis of the Uranium Fuel Cycle II: Nuclear Power Reactors* (Washington, D.C.: EPA-520/9-73-003-C, 1973), Table 40.

**25.** L.H. Hempelmann and others, *Journal of the National Cancer Institute*, 55 (1975), p. 519.

**26.** U.S. FDA, *Proposed Recommendations on Use of Potassium Iodide as a Thyroid Blocking Agent in a Radiation Emergency* (April 1981). For an early release, the thyroid dose from the 21-hour half-life isotope iodine-133 would be approximately one-third that of iodine-131. In March 1954, 22 Marshallese children on Rongelap atoll received an estimated 700 to 1,200 rem thyroid dose from drinking water contaminated with such short-lived radioiodines from the "Bravo" H-bomb test. Almost all subsequently required thyroid surgery and were put on lifetime thyroid hormone medication. (Robert A. Conard and others, *Review of the Medical Findings in a Marshallese Population Twenty-Six Years After Accidental Exposure to Radioactive Fallout* [Brookhaven National Laboratory, BNL 51261, 1980].)

**27.** A detailed discussion of the derivation of Figures 5 and 6 may be found in, Jan Beyea and Frank von Hippel, *Nuclear Reactor Accidents: The Value of Improved Containment* (Princeton University, Center for Energy and Environmental Studies Report #94, 1980).

**28.** Although it is not possible to filter out the noble gases, doses in excess of 10 rem would be received from the noble gases over an area which would be smaller than 1 percent of 10,000 square kilometers.

Senator **Domenici**. Thank you, very much. Did you recommend the tax on just nuclear power?

Dr. **Beyea**. At this point, yes, sir.

Senator **Domenici**. Why do you not put the tax on coal generating power, also?

Dr. **Beyea**. Well, we might go along with that, too, but in terms of the political climate, I think there is a political possibility at this time to put a tax on nuclear power that the public would accept.

Senator **Domenici**. Well, I think some of us would more readily accept it if it were shared. Environmental problems are not unique to nuclear. If we invent a new reactor, it apparently would be available also to solve some of the problems that coal presents; would it not?

Dr. **Beyea**. If you are trying to suggest that I would oppose a tax on coal, I would not necessarily oppose a tax on coal.

Senator **Domenici**. No, I really was not. I was just wondering, and you gave me the answer. You think it is more vulnerable now so it would be supported, if I understand you correctly.

Dr. **Beyea**. I think there is a recognition on the part of the public that nuclear power has problems—at least this generation of plants—has problems that are not desirable. And I think that you must do something to respond to that concern. One response that you have heard today by Howard Denton is to do little immediately; perhaps work on the GE containment.

Another response is to go back to the public and say, we recognize there is a problem and we want to do something about it. It is going to take some money to do that, and will you support that kind of tax?

Senator **Domenici**. Let me ask you one other question. The Audubon Society has—you work for them?

Dr. **Beyea**. That is correct.

Senator **Domenici**. What kind of scientific staff, aside from you, do they have? Are you it, or do they have a number of them?

Dr. **Beyea**. We have, in terms of scientific staff, we have about six Ph.D.'s that cover all our topics, mainly wildlife; most of the Ph.D. staffs are associated with wildlife. There are two Ph.D.'s that are relevant to this field. I have a staff of three full time people who also work with me.

Senator **Domenici**. Since you are telling us that recommendations have not been made yet but they are going to be obviously, at some point, you are giving this committee advance of what you are thinking about, if I gathered your testimony right.

What is the process by which the Audubon Society will make their decision?

Dr. **Beyea**. What we will do, and what we have done with our previous reports on energy is to circulate them to a wide range of people, our friends and our enemies, to get their response. We will be circulating these ideas to other environmental groups to see if they can generate any support among those groups.

We also will be sending this testimony, these ideas, to people in the nuclear industry to see what their comments are.

We believe that it is time that we talk to each other and we intend to do that.

Senator DOMENICI. I appreciate the answer. Thank you, very much.

Mr. Taylor, would you do me a favor—probably we could get this information somewhere else, but nonetheless, if you have it—you gave us the example of cancer from the high-level radiation resulting from the bomb. I understand Dr. Beyea thinks it might not be totally relevant, and I am not going to pass judgment on that.

But, can you furnish us or give us the source of that information so that someone like myself and other members would be able to talk about it, examine and see what those numbers mean?

Mr. TAYLOR. It comes from the U.S. Commission that was designated to follow up on the survivors of the bombings, and I can give you the exact terminology, location, and I will do that.

Senator DOMENICI. Would you do that through our staff, please?

Staff, would you put that together, at least for this Senator and circulate it if anybody else is interested; I would like to have that myself, in all events.

What is an inherently safe reactor mean?

Mr. TAYLOR. I would like to comment. I don't think there is anything in this world, Senator, that is inherently safe. There has been a tradition in the nuclear power industry in the United States to take advantage of intrinsic features in the systems that will make them more stable and easier to control. The very earliest discover, with great glee, was that it was possible to have a negative temperature coefficient.

That is, if the temperature of the reactor went up, the reaction rate went down. So you had built in the physical laws of the system a tendency to keep stable. We have maintained that as a very important design feature.

Another one is the natural circulation, the capability for coolants to, by thermal convection, provide cooling without the need for pumping, and equipment to move the coolant around.

Another in the liquid metal systems has been what is called the Dopplar coefficient, an effect, again a physical law in the fuel. As the power goes up, there is a tendency for the reaction rate to come down, and the gas-cool reactor, one of the benefits of graphite is that it represents, in the way it is operated in this country—not necessarily in the Soviet Union—a large heat sink which captures excess heat and minimizes the need for people to act immediately.

I think from our experience, we should enlarge on the contribution of these intrinsic safety features in all our systems; light-water, gas-cooled, and liquid metal.

But to say that we could carry them to the point that we have intrinsic safety, it is a Madison Avenue statement.

Dr. DEAN. I agree with much of what Mr. Taylor said, but when we use the word "inherently" safe, passively safe, this is a reactor design which has the power limited such that there can be upsets in the system, that operator action is not required; that no automatic powered safety systems must come into operation to protect the health and safety of the public.

For example, if you were to lose feedwater. You lose it, the operators don't have to worry about reestablishing feedwater to protect the safety of the public. The reactor is located underground and it can lose all power, all cooling, except the cooling that naturally occurs to the Earth. It is intrinsic; the laws of nature would prevent the fuel from overheating, such that it would release the fission products just because the earth is still surrounding.

That is an example of the inherent safety features of the modular HTGR.

Senator DOMENICI. Dr. Beyea, when you mentioned proceeding with the research for the next generation, generally you were alluding to the same kind of technology that they have been talking about?

Dr. BEYEA. That Dr. Dean has been talking about. Technology that relies on basic physical principles, chemical principles, or its safety does not rely on mechanical equipment.

Senator DOMENICI. I have to close the hearing down. I have about four or five written questions that I would submit for your response. But, I would ask, since I do not have it prepared, if you, Mr. Pate, or any of you, would take the quote from the newspaper article that Senator Metzenbaum used, indicating, whoever wrote it, their version as written about accidents since Three Mile Island.

I wonder if somebody could do an analysis of that and tell us what you think it means, or if it does not state the case as you see it, prepare written remarks so that we would have that in the record. Could you do that for us?

Dr. PATE. Yes, sir. I would be pleased to.

Senator DOMENICI. All right. Anybody else could do that or—is it outside their——

Mr. TAYLOR. I would be glad to respond, also, Senator.

Senator DOMENICI. All right. I really did that because I do not understand that threshold issue described by the NRC, and these. So somewhere, there is some definitional change that has occurred, it appears to me, or somebody is way off base.

All right, if there is nothing further, let me before we close say to you, Dr. Schulten, we are very appreciative that you would be here and that you would take so much time and effort on your own to come from your homeland to ours. We appreciate that very much. And, to the rest of you, we are most appreciative.

We will recess the hearing until the call of the Chair.

[Whereupon, the hearing was recessed, subject to the call of the Chair.]

# APPENDIX

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## RESPONSES TO ADDITIONAL COMMITTEE QUESTIONS

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JUL 22

OFFICE OF
EXTERNAL AFFAIRS

Honorable James A. McClure
Chairman
Committee on Energy and
Natural Resources
United States Senate
Washington, D.C. 20510

Dear Mr. Chairman:

Enclosed are our responses to the questions contained in your June 30, 1986 letter to Sheldon Meyers, Director, Office of Radiation Programs, who testified before the Committee on June 19, 1986 concerning the Chernobyl accident and its implications for the domestic nuclear industry.

If I can be of further assistance, please let me know.

Sincerely,

Jennifer Joy (Manson) Wilson
Assistant Administrator
for External Affairs

Enclosure

RESPONSES TO FOLLOW-UP QUESTIONS TO JUNE 19, 1986 HEARING BEFORE THE SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES

Q1. Why are there so few federal monitoring stations in Alaska when the Arctic is a known "sink" for atmospheric pollutants, and the first traces of radioactivity over North America resulting from Chernobyl were located over the Gulf of Alaska?

A1. The Environmental Radiation Ambient Monitoring System (ERAMS) is a nationwide monitoring program that is operated jointly by State and local personnel and the U.S. Environmental Protection Agency (EPA). EPA provides the sampling equipment, supplies, and laboratory analyses of samples. State and local governments provide the personnel that collect the samples and pay for the electricity required to run the samplers. In the event of an incident such as Chernobyl, radioactivity will be first detected in air and precipitation. There are 67 ERAMS stations that collect air particulates and precipitation. With the exception of Maryland and Massachusetts, there are one or more air sampling stations in each of the fifty States. Because nuclear debris from incidents like Chernobyl or foreign tests of nuclear weapons in the atmosphere is widely dispersed in the atmosphere, this distribution of the 67 stations is sufficient to monitor the track of air contamination as it moves across the United States and to determine if additional sampling (milk, food, and water) or other actions are required.

In Alaska there are two air particulate sampling stations and milk samples are collected from the Palmer, Alaska, milk shed. The air particulate stations in Alaska, located in Anchorage and Juneau, are maintained in a ready standby mode and can be activated by phone, as required. Following the Chernobyl accident both stations operated continuously until June 1 when atmospheric radioactivity had returned to near normal levels. Milk was collected twice per week through the month of June when the normal monthly sampling program was resumed.

We believe that the monitoring stations in Alaska are sufficient to provide early warning of contamination and allow appropriate protective actions to be taken. However, if the State or the Arctic Research Commission is willing to provide personnel to operate stations, we would be happy to discuss the number and location of additional monitoring sites in Alaska.

Q2. The major monitoring response to the Chernobyl accident was by State and University personnel primarily because of a perceived insufficent Federal capacity to respond. In light of the ad-hoc nature of the monitoring program in Alaska, and the presence of several University, State, and Federal groups involved in monitoring, do you see a role for the Arctic Research Commission to help coordinate the monitoring program?

A2. As noted above, we would be glad to consult with the Arctic Research Commission in identifying operators and station locations.

Q3. Are the nuclear particles that are being monitored by EPA representative of the nuclear particles that could be produced by an accident at any of the existing nuclear power plants around the world? --- or are there "holes" in our particle monitoring capability?

A3. We feel our monitoring program provides adequate coverage to detect any major release of radioactivity in the environment as it traverses the United States at the lower altitudes. As far as "holes" in our monitoring capability, any program can be more detailed and extensive with more sampling sites and analyses; however, this must be balanced with other programs and the resources and personnel available.

Q4. Is there any merit to the claims that our nuclear fallout monitoring capability is insufficient to protect the safety and health of our citizens? ...i.e., are there dangerous particles in the atmosphere that we don't or can't monitor?

A4. We feel that our national monitoring system which analyzes major radionuclides and pathways of concern is sufficient to protect the safety and health of U.S. citizens. We do not routinely monitor for gaseous radionuclides. We are presently considering the monitoring of gaseous radioactivity at a representative number (20) of the present air particulate stations.

Q5. Please explain, in layman's terms, the situation with respect to radioactivity levels at and around the Chernobyl plant, and to a distance of 18 miles.

How much activity will be allowed within the 18 mile radius of the plant over the next year and longer periods of time?

A5. As of this time, we have not received information from the U.S.S.R. that we would need to address this question. The Soviets are giving a briefing on the Chernobyl accident in Vienna, Austria, at the end of August. We hope this forum will provide the information needed to adequately address your questions.

# U.S. NUCLEAR REGULATORY COMMISSION

# RESPONSES TO QUESTIONS

ON

# CHERNOBYL ACCIDENT AND IMPLICATIONS FOR DOMESTIC NUCLEAR INDUSTRY

HEARING OF JUNE 19, 1986

SUBMITTED TO THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE

AUGUST 1986

QUESTION 1. Some people have said that the Chernobyl reactor did have a containment system of sorts. But as I understand it, the reactor had merely a pressure suppression system and other safety features that were designed more to protect the reactor from damage, as opposed to protecting the public from injury. Can you elaborate on this?

ANSWER.

Our present understanding of the design of the Chernobyl Unit 4, reactor that was involved in the recent accident is based on available documents and discussions with technical experts familiar with Soviet reactor technology. That information is not sufficient to allow a complete understanding of the reactor and containment design at this time. However, it is clear that the Chernobyl design did not have a containment structure surrounding the primary reactor system such as is used on U.S. licensed reactors.

Portions of the Chernobyl reactor design perform some of the same functions as in the U.S. licensed designs. However, the designs are not directly comparable. In the Chernobyl design, the fuel is held in fuel tubes containing multiple fuel elements and the cooling water. These fuel tubes are designed for pressures approximately equal to the design pressure of the fuel elements in some U.S. reactors (about 1500 psig). The fuel tubes are then enclosed in a graphite matrix used as the moderator and is part of a region of the Chernobyl design referred to as the "vault". We do not believe that the part of the vault that surrounds the fuel and graphite has any appreciable pressure retention capability. The Chernobyl plant does contain certain compartments that are designed to withstand piping failures in those compartments, as well as a pressure suppression system utilizing pools of water as in U.S. boiling water reactors.

In summary, there does not appear to have been any structure at Chernobyl having an appreciable pressure retention capability surrounding the reactor core, equivalent to the containments used in U.S. plants.

Commissioner Asselstine adds the following:

I agree with the Commission statement that information about the Chernobyl plant design is not sufficiently detailed to allow a complete understanding of the design at this time. However, I believe that the Commission's response creates an overly optimistic impression of U.S. containment performance as compared with the Chernobyl design. For example, the Commission's response fails to mention the existence of primary system equipment outside the containments in U.S. reactors or the existence of pathways which could bypass U.S. containments.

For U.S. pressurized water reactors, a significant portion of the area of the primary reactor system consists of thousands of steam generator tubes, which at many reactors are cracked and/or corroded. A rupture of those tubes represents a containment bypass release scenario in that the secondary side of the steam generators is isolated from the environment by relief valves, not a containment structure. In U.S. boiling water reactors, the primary core coolant path exits the containment structure. In both types of U.S. plants, there are piping connections to the primary reactor system which exit the containment structure and which have design pressures far below that of the primary system piping. Thus, U.S. reactors have built-in containment bypass pathways. This is not to say that each core meltdown in a U.S. plant would result in substantial offsite releases.

With regard to the Soviet Union reactor designs, I agree with the Commission that their plants have different designs than U.S. plants. However, there appear to be some interesting similarities in the design bases which were used here and in the Soviet Union. In the attached response to Question C.4 (which was provided to the Commission by the NRC staff as background information for a Congressional hearing in May), the staff wrote that the Chernobyl reactor and portions of the inlet and outlet piping were surrounded by a "vault" with a design pressure of 27 psi which was in turn connected to a pressure suppression pool. This information provided the basis for my previous comments on the Chernobyl and U.S. containment designs. The NRC staff is now saying that the overall core region surrounding the fuel and control rods does not have any appreciable pressure retention capability. However, the plant does contain certain compartments that are designed to withstand piping failures, as well as a pressure suppression system. The design basis for the plant appears to be similar to that for U.S. plants. The Commission's regulations are founded on a postulated break of the largest pipe in a zone or a break in one of the thousands of steam generator tubes. The Commission deems multiple ruptures beyond the design basis. For this and other reasons, the U.S. plants have vulnerabilities to substantial releases of radioactivity off-site in the event of a large-scale core meltdown accident. So do those of the Soviet Union.

I believe the principal issue raised by the Chernobyl accident is not whether the plants in the Soviet Union have a different design than those in the United States. Rather, recognizing that the estimated quantity of fission products released at Chernobyl could be equaled or exceeded by a core meltdown accident at a U.S. plant, the issues raised are: Do the U.S. reactor containments have sufficient capabilities for coping with core meltdown phenomena and have we done enough to prevent core meltdown accidents?

QUESTION C.4. WHAT DO WE KNOW ABOUT RUSSIAN PRACTICE REGARDING SAFETY FEATURES SUCH AS CONTAINMENT VS. CONFINEMENT?

ANSWER.

UNIT 4 AT CHERNOBYL CONTAINS CHARACTERISTICS OF BOTH CONTAINMENT AND CONFINEMENT. THERE ARE TWO REGIONS THAT APPEAR TO BE DESIGNED TO WITHSTAND 27 PSI AND 57 PSI. THESE VOLUMES ARE IN TURN INTERCONNECTED WITH TWO SUPPRESSION POOLS VIA PRESSURE RELIEF VALVES AND DOWNCOMERS. THE REMAINING PORTIONS OF THE PLANT ARE HOUSED WITHIN A CONFINEMENT STRUCTURE. FOR PURPOSES OF THIS DISCUSSION, THE CONFINEMENT BUILDING CAN BE CONSIDERED AS A FILTRATION SYSTEM WITH LITTLE OR NO PRESSURE RETENTION CAPABILITY.

THE FIRST CONTAINMENT REGION, REFERRED TO AS THE REACTOR VAULT, IS SHOWN IN THE ENCLOSED FIGURES. IT SURROUNDS THE REACTOR AND PORTIONS OF THE INLET AND OUTLET WATER PIPING. THE DESIGN PRESSURE IS .18 MPA (27 PSI). AT LEAST TWO RELIEF VALVES CONNECT THIS REGION TO THE SUPPRESSION POOL(S). THE SETPOINT OF THESE VALVES IS .02 MPA (3 PSI). ENCLOSED PIPING CONSISTS OF RELATIVELY SMALL DIAMETER (I.E., 6 INCH DIAMETER) TUBING THEREBY ELIMINATING THE NEED FOR A HIGHER DESIGN PRESSURE.

THE SECOND CONTAINMENT REGION ENCLOSES THE MAJOR DIAMETER PIPING AND HEADERS OF THE SYSTEM. THE LARGEST PIPE IN THIS VOLUME IS 90 CM (35 INCH) IN DIAMETER. THE BOUNDARY OF THE ENCLOSED VOLUME IS SHOWN IN THE ATTACHED FIGURE. THIS REGION HAS A DESIGN PRESSURE OF .35 MPA (57 PSI). DOWNCOMERS CONNECT THIS REGION TO THE SUPPRESSION POOLS. THE SUPPRESSION POOLS ARE ARRANGED ONE ON TOP OF THE OTHER, AS SHOWN IN THE ATTACHED FIGURE. EACH POOL REGION IS APPROXIMATELY EIGHT FEET HIGH WITH A POOL DEPTH OF ABOUT 4 FT.

WE ARE NOT AWARE OF ANY OVERHEAD SPRAY SYSTEMS OR DYNAMIC COOLING SYSTEMS INSIDE OF THE CONFINEMENT BUILDING SIMILAR TO THOSE USED IN U.S. LWRS.

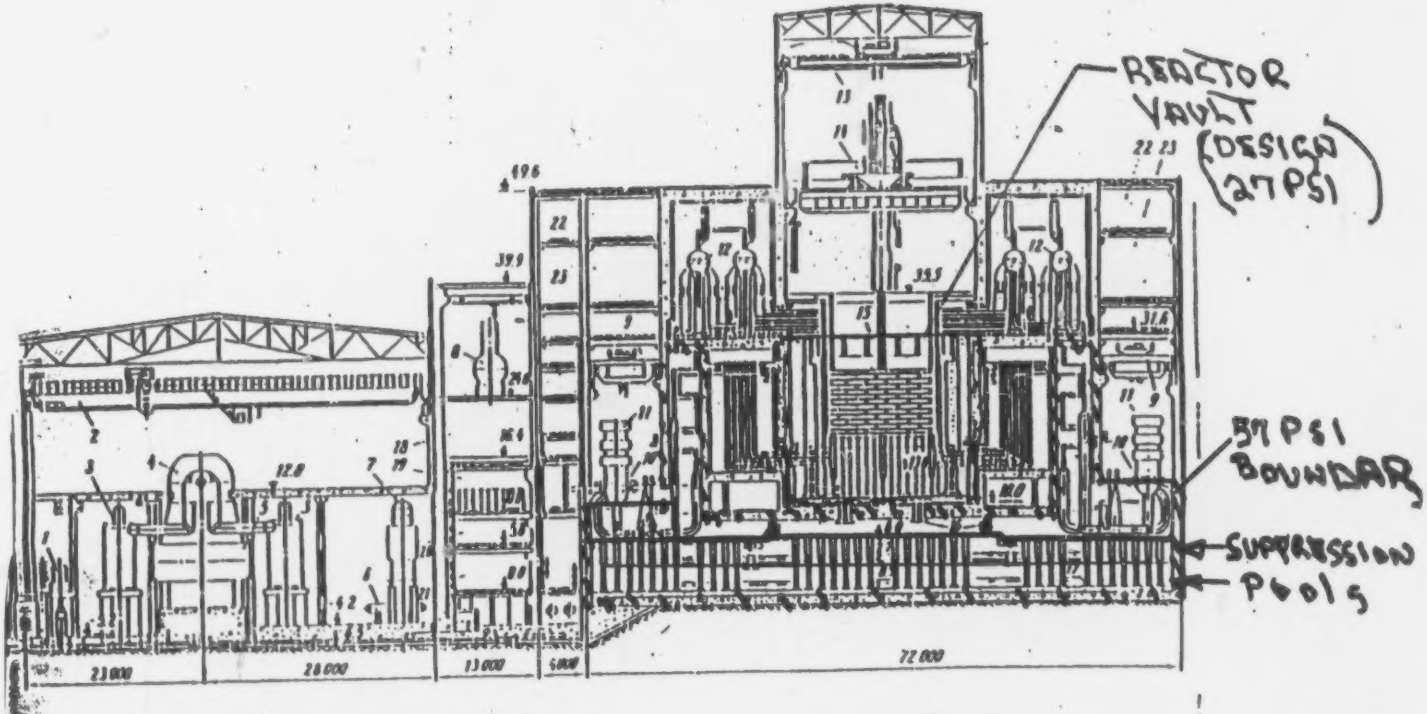
REACTOR VAULT (DESIGN 27 PSI)
57 PSI BOUNDAR
SUPPRESSION
Pools
49.6
39.9
33.5
31.6
12.8
22
23
22 23
1
2
3
4
5
7
8
9
11
12
13
15
18
19
21
23 000
28 000
13 000
6 000
72 000

Fig. 2. Cross-sectional view of the main building at Smolensk

1—first-stage condensate pump; 2—125/20 t overhead travelling crane; 3—separator-steam superheater; 4—K-500-65/3000 steam turbine; 5—condenser; 6—additional cooler; 7—low-pressure heater; 8—deaerator; 9—50/10 t overhead travelling crane; 10—main circulating pump; 11—electric motor of main circulating pump; 12—drum separator; 13—50/10 t remotely controlled overhead travelling crane; 14—refuelling mechanism; 15—RBMK-1000 reactor; 16—accident containment valves; 17—bubbler pond; 18—pipe aisle; 19—modular control board; 20—location beneath control board room; 21—house switchgear locations; 22—exhaust ventilation plant locations; 23—plenum ventilation plant locations

REACTOR VAULT

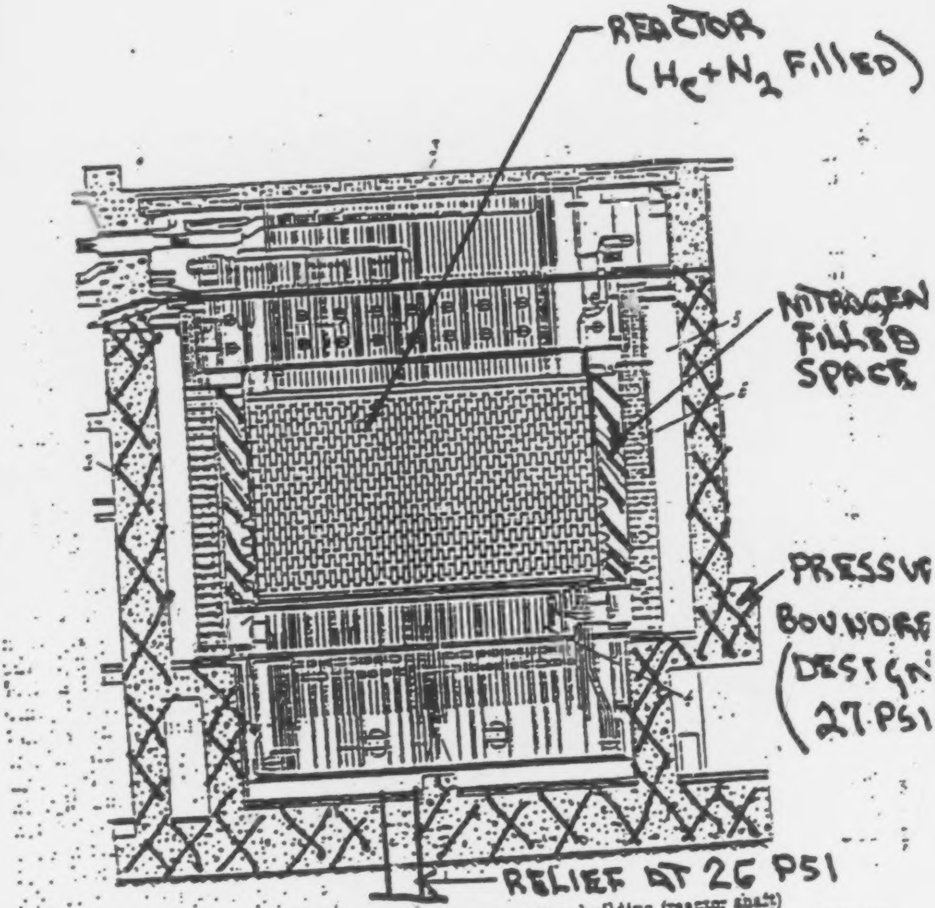
REACTOR
(He+N2 Filled)
NITROGEN
FILLED
SPACE
PRESSU
BOUNDRY
(DESIGN
27 PSI
RELIEF AT 26 PSI
1
2
3
4
5
6

Fig. 3 Cross-sectional view of an RBMK-1000 reactor station building (reactor shaft) 1—sand; 2—steel blocks; 3—ordinary concrete; 4—iron-barium-serpentinite-cement block; 5—serpentinite; 6—water

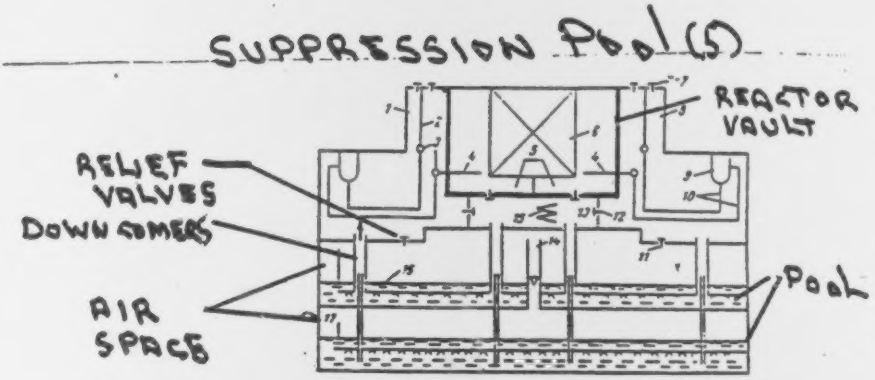
SUPPRESSION Pool (5)
REACTOR VAULT
RELIEF VALVES
DOWN COMERS
AIR SPACE
Pool
1
2
3
4
5
8
4
9
10
15
13
12
14
11
17

Fig. 1. Schematic diagram of gas-tight box: 1, 8—gas-tight box (emerg and non-emergency halves respectively); 2—downcomer lines; 3—collector main circulating pumps; 4—distributing group collectors; 5—lower water compartment; 6—reactor; 7—safety valve; 9—main circulating pump; 10— circulating pump lines; 11—bypass valve; 12—check valve panel; 13—low water line check valve; 14—overflow tube; 15—surface type heat exchang 16—steam dump lines following main safety valves; 17—bubbler tank

QUESTION 2. What are the main safety issues that you believe might have to be revisited in the U.S. as a result of "lessons learned" from Chernobyl?

ANSWER.

There are three main areas which the NRC will examine for "lessons learned" as a result of the Chernobyl accident. The first area deals with those issues involving accident prevention. The NRC will attempt to identify the initiating event, the relationship of the Chernobyl plant design to the accidents and transients that could occur in plants of that design, and to assess the likelihood of such events. This relationship will be compared to U.S. plants to systematically identify any similarities and differences. The NRC will also be examining the USSR approach to safety features that can potentially reduce radiological consequences, such as containments, and at severe accident management and accident recovery procedures.

The second area the NRC will investigate deals with the issues involving emergency response planning. This includes international cooperation and early warning programs as well as reassessing the adequacy of current U.S. programs in light of any lessons learned from Chernobyl. The NRC will be involved with wide range planning efforts regarding radiation assessment, food chain impacts, and other environmental impacts. Close coordination with other U.S. agencies, such as the Environmental

Protection Agency and the Food and Drug Administration, will be required.

The third and last major area is source term and accident consequences. A major effort will be to examine how the radiological release mechanism that occurred at Chernobyl apply to U.S. reactors, and whether the NRC's current model's ability to predict radiological source terms remain valid. The validity of current meteorological models for transport of radionuclides in the atmosphere will also be investigated.

Commissioner Asselstine adds:

In my judgment, there are several lessons that we can learn from Chernobyl and should apply to the U.S. nuclear program. Some of these lessons reinforce previous safety decisions made in this country. In this vein, the Chernobyl accident seems to demonstrate the wisdom of some of the new safety requirements adopted in the United States in the wake of the Three Mile Island accident in 1979. One example is improved emergency planning around commercial nuclear power plants, which provides an added measure of public protection, independent of plant safety systems, to mitigate the consequences of an accident resulting in the offsite release of radioactivity. Another example is the addition of hydrogen control features on certain types of plants which are intended to prevent large-scale hydrogen explosions that could breach the reactor containment. And still another example is the environmental qualification of electrical equipment which is intended to ensure that necessary safety equipment will continue to function under serious accident conditions such as heat, moisture and radiation. All of these measures reflected a recognition after the Three Mile Island accident that severe reactor accidents involving the melting of the reactor core and the potential release of substantial amounts of radioactivity can in fact occur. Obviously, the Chernobyl accident reinforces the validity of that judgment.

But perhaps the most important lesson of the Chernobyl accident has to do with the acceptability of a severe accident in the United States and the adequacy of the measures now being taken by the industry and the NRC to prevent such an accident. For this accident brings home the fact that severe reactor accidents which involve melting of the reactor core, the potential for dangerous exposures to radiation, the potential for extensive land contamination, and public stress and trauma, can occur. The fundamental lesson from Chernobyl must be that such an accident is simply unacceptable, and we must make every effort to reduce or eliminate the chance of such an accident in this country. The central question is whether our present regulatory approach and the level of performance of the U.S. plants are fully consistent with this most fundamental lesson of Chernobyl. I must conclude, based upon the experience of the past few years, that they are not, and that we should be pursuing additional features both to reduce the possibility of a core meltdown accident in this country and to mitigate the adverse effects of such an accident should one occur.

Foreign experience demonstrates that there are practical and reasonable options available to reduce the severe accident risk in this country as well. I would propose a three-part program to achieve this objective. First, each of the 100 operating plants in the U.S. should be reexamined to identify design deficiencies and vulnerabilities, of the type seen in our recent serious operating events and plant safety analyses, that could cause or contribute to a severe accident. Second, improvement programs should be required in areas of demonstrated weak performance at the U.S. plants such as management, maintenance, personnel performance and equipment reliability. Our objective should be to bring all U.S. plants up to the highest standards of operating performance being achieved in other countries. We should insist upon rapid improvement in the case of those U.S. plants with a history of poor performance.

Third, new design features should be considered for existing and future U.S. plants which have the potential to reduce both the likelihood and the consequences of a core meltdown accident. The design features being added in foreign plants, such as an added independent decay heat removal system, improvements in the reliability of reactor control systems and emergency power supply systems, systems to protect against the loss of power to operate cooling and safety systems, and systems to allow the controlled venting from some reactor containments, provide a good starting point for this review.

Taken together, these measures should lead to a substantial reduction in the risk of a core meltdown accident in this country. They would also represent a return to the vigilant and forward-looking safety philosophy advocated by the President's Commission on the Three Mile Island Accident. If we are to heed the lessons of the Chernobyl accident, we must return to a safety approach that stresses the need to improve plant performance, to learn the lessons of operating experience, and to pursue practical safety improvements in existing as well as any future plants in order to reduce the risk of a core meltdown to a level that is as low as reasonably achievable.

QUESTION 3. Just to set the record straight, what is the population within a 10-mile radius of Shoreham?

ANSWER.

The population within a 10-mile radius* for the Shoreham Nuclear Power Station is as follows:

| | 1985 POPULATION (PROJECTED) | |
|---|---|---|
| | WINTER | SUMMER |
| 0-10 miles | 138,500 | 160,000 |

(SOURCE: Shoreham Nuclear Power Station Local Offsite Radiological Emergency Response Plan, Revision 6, January 1986)

*Population data is for the plume exposure pathway Emergency Planning Zone which is about 10-miles in radius.

QUESTION 4. What is the population within a 10-mile radius of Indian Point?

Answer.

The population within a 10-mile radius of the Indian Point Nuclear Power Plant is as follows:

| | 1990 Population (Projected) |
|---|---|
| 0-10 miles | 247,400 |

(Source: NRC Staff Testimony in Indian Point Special Proceeding, January 24, 1983)

QUESTION 5. If you were to choose between the current licensing process and the revised process proposed in legislation submitted by NRC and DOE to Congress, which process is better in terms of enhancing the safety of nuclear power? Which process is preferable in terms of meaningful public input? Which process would lead to a better technology, a more streamlined construction and licensing time-period, a more reliable power plant, and lower electricity costs for ratepayers?

ANSWER.

The following answers are based on the provisions of S. 836, the NRC proposal, without attempting to account for differences in S. 2073, the DOE proposal. As the Commission indicated in testimony before the Senate Committe on Energy and Natural Resources earlier this year, however, the differences between the NRC and DOE legislative proposals are small. Therefore, they would not likely affect the answers given below.

The revised licensing process in the proposed legislation would result in the development of more complete information at an earlier stage of the licensing process. Standardization would foster improvements in design, management, and operation of nuclear plants. It would also facilitate operator training and exchange of technical information. These improvements should enhance the safety of nuclear power. The proposed legislation would also provide an opportunity for public participation at a more appropriate stage of the licensing process; after significant design information is made available but before construction is allowed to begin. This would make public input more meaningful. Because of improved safety, as discussed above, the licensing process in the proposed legislation would be more likely to lead to a better technology and a more reliable power plant. By requiring some issues to be decided earlier and by precluding relitigation of issues except in carefully defined circumstances, the licensing process in the proposed legislation would also result in a more streamlined construction and licensing period, which should reduce the time and, therefore, the cost of constructing a nuclear power plant and placing it into operation. This, coupled with increased reliability of nuclear power plants, should result in lower electricity costs for ratepayers, assuming no increase in such costs that could be attributed to other factors.

Commissioner Asselstine adds:

I favor encouraging standardization. However, I have two fundamental concerns about the licensing process as proposed by both the NRC and DOE bill.

First, I believe that we should require the use of standardized designs and that a standardized design be essentially complete. The proposals allow for the use of custom designs and permit approval of something less than a complete standardized design. This can only perpetuate the problems encountered to date with custom designs which were caused by trying to design as one built the plant.

Second, I believe that the public should have an opportunity for a hearing at the preoperational stage. The bills as now written provide at best a discretionary hearing at that stage. Several issues cannot be raised earlier in the process -- emergency planning, operational readiness and whether the plant has been built as designed and in accordance with regulations. The public should have an opportunity for input on this kind of issue before the plant is allowed to operated.

QUESTION 6. Could you tell us what the NRC's budget profile for safety research has been over the last 4 years?

ANSWER.

NUCLEAR REGULATORY RESEARCH
PROGRAM SUPPORT FUNDS
FY 1983 - FY 1986
(DOLLARS IN MILLIONS)

| | FY 83 | FY 84 | FY 85 | FY 86 |
|---|---|---|---|---|
| Reactor Engineering | $35.3 | $43.4 | $38.8 | $36.5 |
| Thermal Hydraulic Transients | 35.6 | 36.9 | 24.0 | 18.7 |
| LOFT | 15.0 | - | - | - |
| Accident Evaluation | 48.0 | 44.5 | 37.4 | 28.6 |
| Reactor Operations & Risk | 25.7 | 20.1 | 16.6 | 14.2 |
| Advanced Reactors | 9.1 | 8.9 | 2.6 | - |
| Waste Management, Earth Sciences & Health | 20.6 | 19.1 | 13.6 | 11.2 |
| TOTAL | $189.3 | $172.9 | $133.0 | $109.2 |

QUESTION 7. Do we now have any in-pile safety testing capabilities in this country? Where would one have to go to get answers to safety questions requiring such capabilities?

ANSWER.

There is one safety test facility still available in the U.S. for safety tests on short segments (12 to 18 inches long) of light water reactor fuel rods: the Annular Core Research Reactor at Sandia National Laboratories. Other test facilities used in the past are LOFT and PBF at Idaho National Engineering Laboratories. LOFT has been disassembled and PBF is on standby awaiting decommissioning. The Annular Core Research Reactor is used by DOE's Defense Program activities as well as by NRC research programs.

Through an international agreement, NRC has sponsored tests of full length LWR fuel rods at Canada's NRU reactor. In addition, France has a small test reactor called PHEBUS that is carrying out a program of transient tests similar to some of the tests carried out earlier in the U.S. The PHEBUS reactor may be upgraded to have a steady state capability like the PBF; this upgrade is unlikely before 1990 at the earliest. We are continuing to negotiate with the French CEA regarding an agreement for sharing in the work at PHEBUS.

QUESTION 8. Wouldn't having uniform, standardized plants make NRC's work more focused and efficient in terms of regulating, licensing, inspecting, training, and providing safety in nuclear power plants?

ANSWER

Yes. Standardization would greatly enhance the NRC's regulatory responsibilities related to licensing, inspecting and training. Available resources could be concentrated on fewer designs, allowing the development of a greater base of experience and ~~evaluation~~ skills. The staff's effort would be enhanced by avoiding the dilution inherent in spreading the resources among many designs with different systems and operating parameters.

QUESTION 9. You attended the IAEA special meeting of the Board of Governors after the Chernobyl accident. What follow-up activities were proposed at this meeting, and what role does NRC play in these IAEA activities?

ANSWER.

NRC will participate in several upcoming IAEA meetings over the next several months. The first will be a meeting, (expected in late August) during which the Soviet Union will report on the causes of the Chernobyl accident. There will also be meetings in which binding international early warning and coordination agreements will be drafted. There will be a meeting of worldwide experts that will develop and propose ways to improve safety. The final meeting will be a conference of governments convened to consider the recommendations of the experts meeting. In addition to these meetings, there is also underway a general movement to strengthen the role of the IAEA in responding to accidents such as Chernobyl. For example, the role of the Operational Safety Assessment Review Teams will be strengthened through mechanisms such as increasing the inspection frequency. The Incident Reporting System will likewise be improved.

The NRC has been informed that the International Nuclear Safety Advisory Group, which advises the IAEA Inspector General, will also be strengthened. Finally, other U. N.-sponsored organizations, such as the U. N. Scientific Committee on Effects of Atomic Radiation, and the World Health Organization will become more actively involved in responding to nuclear accidents.

In addition, the NRC actively participates in activities of the Committee for the Safety of Nuclear Installations, which operates under the auspices of the OECD's Nuclear Energy Agency. This Committee is beginning to become actively involved in the assessment of the Chernobyl accident.

A group of senior NRC scientists and engineers has been appointed to continue the study of the accident and recommend to the Commission any action that might be needed for the U.S. nuclear regulatory program.

QUESTION 10. A year ago, the NRC staff stated, in response to a House Committee inquiry, that there was a 50% chance of a severe core damage accident in one of the 100 plants operating in the U.S. over the next 20 years. More recently, the NRC staff revised their estimate, in light of post-TMI improvements, to only one chance in eight (12%) for the 100 plants operating over the next 20 years. I think this data is somewhat misleading because a severe core accident doesn't by any means translate into public injury. In fact, the TMI accident was 70% core meltdown accident, and no significant amounts of radiation were released to the public.

In terms of public consequences, then, what are the probabilities that a severe core damage accident, should that occur in any U.S. reactor, would result in significant offsite release of radiation?

ANSWER.

It is true that in calculating the probability of a severe core damage accident almost all probabilistic risk assessments (PRAs) assume that loss of core cooling invariably leads to massive core melt, subsequent reactor vessel failure and challenge of the containment. In fact, these assumptions are only valid for specific sequences, that involve failure of operators to take certain actions and/or non-recoverable failure of safety systems. Our current estimates suggest that given the sequences involving a loss of core cooling, there exists approximately a 1 in 2 to 1 in 10 chance that the damaged core will be arrested and remain inside the reactor vessel.

If the damaged core remains in the vessel, as happened at TMI, the offsite radiological releases would be very low as has also been predicted by PRAS. Moreover, even if the core melts through the vessel and enters the containment, if the containment sprays or other such mitigating features provided, remain functional there is a high probability that containment integrity will be maintained with negligible offsite consequences.

However, there are low probability events that can be postulated which involve not only the failures which produced the core meltdown, but also involve failures of containment sprays and heat removal systems. In these cases containment failure is predicted to occur. The consequences though, will depend on the specific containment design, design features of the plant, and site characteristics.

Commissioner Asselstine adds:

There is no precise and reliable quantitative answer to the question. Rather, there are quantitative and qualitative indications that taken together serve as the basis for any estimate of the likelihood of a core melt accident.

With regard to quantitative indications, the Commission has previously stated that the most complete and recent PRAs suggest core-melt frequencies in the range of $10^{-3}$ per reactor year to $10^{-4}$ per reactor year, with a typical value of $3x10^{-4}$ per reactor year. Based on this latter value as an industry average and given a population of 100 reactors operating over a period of 20 years, the Commission has estimated the likelihood of a severe core melt accident in the next 20 years to be 45 percent. (See the Commission's response to Question 21(a) in the April 16, 1985 letter to Congressman Markey from Chairman Palladino.) The value of 45 percent has been estimated by the Commission through the formula $P=1-e^{-xt}$, where P is the cumulative probability of an event occurring over time t, and x is the likelihood of the event. In this case, t equals 20 years and x equals $3x10^{-4}$ per reactor year times 100 reactors.

The PRA estimates given above have substantial uncertainties that span a factor of about 10 above and below the reported values. I believe it is mandatory that consideration of these uncertainties be factored into any application of such point estimates. Thus, the cumulative probability of a core meltdown accident in the next

20 years, based only on PRA estimates and their uncertainties, ranges anywhere from 0.99 to 0.06. These values have been derived by using the same formula that the Commission has used and by varying x to reflect the factor of 10 uncertainty in the point estimates.

Regarding the upper limit of 0.99, actuarial experience with reactor accidents indicates that the industry average core meltdown frequency is not above $10^{-3}$ per reactor year. Core meltdown accidents involve multiple failures and a progression of events that make close calls somewhat identifiable. If the industry average of the core meltdown frequency were as high as $10^{-3}$ per reactor year, one would expect more close calls on core meltdowns than appear to have occurred within the more than 800 reactor years of the U.S. nuclear power experience. However, such actuarial inferences must be made cautiously in part because the operating reactors continue to surprise us. What actuarial experience we have is severely limited by our lack of detailed understanding of the performance of the plants, their designs, their weak spots, and because of the wide variations in the designs and in utility capabilities. Further, the usefulness of actuarial experience in drawing broad conclusions about commercial nuclear reactors is highly controversial and fraught with uncertainties.

With regard to qualitatitive indicators, I should note that, in the document serving as a significant part of the technical basis for the Commission's Severe Accident Policy Statement, there is the following observation: "There is a distinct possibility of one or more additional severe reactor accidents, beyond the one at Three Mile Island, in the remaining service life of the plants now in operation or under construction, unless the estimated accident frequency declines sharply with modifications, or has been significantly overestimated in current PRAs and actuarial inferences." (See NUREG-1070, "NRC Policy on Future Reactor Designs: Decisions on Severe Accident Issues in Nuclear Power Plant Regulations," August 1984, page 108.) On the question of whether probabilistic risk assessments significantly overestimate core meltdown probabilities, the Commission's chief safety officer has observed: "I believe that the recent Davis-Besse event illustrates that, in the real world, system and component reliabilities can degrade below those we and the industry routinely assume in estimating core melt frequencies. Our regulatory process should require margins against such degradation and also to reflect the uncertainties in our PRA estimates." (See memorandum dated June 27, 1985, from Harold R. Denton to William J. Dircks.) I would also point out that other operating experience indicates that a total loss of a safety system is not a rare event, that multiple independent failures do occur, that there are component and reliability problems, that operating practices are frequently deficient, and that there are a wide range of adverse systems interactions. These actual experiences are not supportive of the notion that a severe accident in the U.S. equal to or more severe than the Three Mile Island accident is an unlikely event over the next 20 years.

Further, many believe that the largest single factor affecting the likelihood of a severe core damage accident rests with the human factor -- the people who manage, operate and maintain nuclear power plants. Whether the contribution is very high or very low depends upon the utilities' commitments, attitudes, actions, and capabilities. Because of the extreme complexity of the plants, mediocrity and complacency on the part of the utilities are not acceptable over the long term. The utilities must have the ability to anticipate problems, react properly to unanticipated events, and adequately maintain and operate their plants. Unfortunately, many utilities do not now meet this test.

As the Commission has recently acknowledged to the Congress, the current generation of nuclear power plants in this country can best be characterized as a complex technology that is not fully mature. Resolution of safety issues over the past thirty years has been left to what one industry executive has called the rough, tough, surly competitive elements. Safety systems are limited because of cost considerations. Containment capabilities are minimized to reduce costs. For example, to keep the containment size down, crucial pumps, heat exchangers, and emergency water supplies have been located outside the containment, which results in flow paths for highly contaminated water that can effectively bypass the containment. Core power densities have been driven to the limits of materials capabilities such that, in the event of a loss of coolant accident, external water supplies must be rapidly injected into the core to keep it from melting. And, the balance of plant is designed to lower standards than the reactor systems to minimize the costs. These competitive forces are what led to the level of safety achieved in the current generation of nuclear power plants and are in part responsible for the poor performance of some of our plants.

Taking the above together and absent fundamental changes in the nuclear industry and in the Nuclear Regulatory Commission, I believe we should expect to see a severe core damage accident at a U.S. plant within the next 20 years.

However, a core melt accident does not automatically mean that there will be significant offsite releases of radioactivity. According to the NRC staff one cannot preclude the release of large fractions of the core inventory. Using extrapolated data, release magnitudes at Chernobyl were, according to the NRC staff, similar to those in the Reactor Safety Study (WASH-1400) release categories PWR 1, 2 or BWR 1, 2. However, uncertainties in atmospheric transport, dispersion, measurements, and other possible release scenarios are such that one cannot preclude radioactivity release magnitudes similar to those in WASH-1400 PWR 3 or BWR 3 release categories. These release categories contain many accident scenarios, including small break loss of coolant with failure of the containment sprays, interfacing systems loss of coolant (i.e., accidents involving overpressurization of low pressure piping that is outside of the containment but is connected to the high pressure primary cooling piping such that the loss of coolant occurs outside of the containment rather than the design basis loss of coolant inside containment), anticipated transients without scram, station blackout, and loss of coolant accidents with failure of emergency core cooling injection.

The specific release category that results from these scenarios is dependent on core meltdown phenomena and containment response thereto. While much progress has been made in understanding these since WASH-1400 was published in 1975, there remain very substantial uncertainties in evaluating them. For example, during a core meltdown, theoretical source term calculations include models for plating out of significant quantities of fission products within the primary system. However, the models do not evaluate or poorly evaluate the effects of the heating of the primary system by the plated-out fission products to determine whether this phenomenon alters the sequence of events and the release category. Steam explosions and their effects on containment and resuspension of fission products are still in dispute. These are just two examples of the many uncertainties and unknowns regarding the release categories which could result from serious core meltdown sequences.

With regard to the likelihood of the various sequences, for the reasons given above I would say that none of the sequences can be ruled out. A number of precursor events have occurred at U.S. reactors for each of the above scenarios.

QUESTION 11. Is there more work that could and should be done to resolve uncertainties associated with the source term issue? What kinds of research are still needed? Do we have the facilities to do the research? Has the NRC proposed this in its FY 87 program plans?

ANSWER:

One of the main objectives of the NRC's Severe Accident Research Program (SARP) has been the identification and resolution of major technical areas of uncertainty arising from the complex phenomena encountered during postulated LWR meltdown events.

In the process of reassessment of the technical bases for estimating source terms; and, in re-evaluating the risk from six representative plants; the NRC and its technical consultants and contractors at the DOE national laboratories have identified twelve well defined areas of uncertainty for which more information is needed. These are:

Core Concrete interaction
Hydrogen generation & burning
Containment venting
Containment Performance
Natural circulation in the primary system
Steam explosions
Direct Containment Heating
Radionuclide revaporization
Chemical form of iodine
Secondary containment effect
Common cause failure
Melt Progression

If no new phenomena turn up, facilities and programs are currently in place to better quantify and reduce the uncertainties in these areas for the current FY 1987 budget plan. The FY 1987 budget includes $29 million for this program. It is expected that these complex areas will require continued research beyond FY 1987, with significant modifications to the existing calculational methodology extending into FY 1989. The detailed program plan is set forth in NUREG-0900 (Rev. 1) - "The Nuclear Regulatory Commission Severe Accident Research Program." The program has also been favorably reviewed by the ACRS in their current report to Congress. Budget projections to carry out this program are as follows:

During the period FY 1982 through FY 1986, the NRC has received about $15 Million in direct contributions and $9 Million in in-kind services from foreign sources for cooperative research in this area. Support from foreign sources is expected to continue in FY 1987 and beyond.

QUESTION 12. The Plant involved in the Davis-Besse Accident has a Babcock and Wilcox Reactor. That reactor has been involved in several serious accidents, including Three Mile Island and Rancho Seco. Even the NRC admitted it has concerns about the safety of the Babcock and Wilcox Reactors.

With such serious warning signals, why does the NRC conclude that plants with these reactors pose no undue risk and should be allowed to keep running without major modifications?

ANSWER.

The utilities have made a significant number of improvements in their plants since the TMI accident to enhance their performance. The staff is concerned that even though utilities have been making these improvements, the number and complexity of events in the B&W plants has not decreased as expected. As a result, we have initiated a reassessment of the B&W plants. This activity will include an assessment of the thermal-hydraulic design, instrumentation, control and power supplies along with a review of operating experience and operator training and response.

The staff believes that the B&W reactors can safely continue to operate while the NRC reassess the B&W plant design requirements.

The recent events at the Davis-Besse plant in June 1985 and at Rancho Seco in December of 1985 have concerned the staff. However, in the case of the Davis-Besse plant, the NRC Incident Investigative Team concluded that the root cause of the event was "The licensee's lack of attention to detail in the care of plant equipment." This was a plant-specific finding.

With respect to the Rancho Seco event, the root cause was identified as "design weakness and vulnerabilities in the ICS" which "were not adequately compensated by other design features, plant procedures or operator training." Information presented to the NRC by the B&W Regulatory Response Group has demonstrated that a loss of ICS power at other B&W plants would not have resulted in as severe an over-cooling event as that experienced at Rancho Seco due to plant design differences and previous actions taken to compensate for a loss of ICS power event.

It should be recognized that these recent events had little or no offsite consequences. Therefore, neither event posed an undue risk to the public health and safety. However, the staff is concerned about the complexity of the post-trip response exhibited by these events. As a result, we have initiated a reassessment of the B&W plants in order to identify potential plant modifications which would improve plant response to anticipated operational transients.

Thus, while the recent events at B&W plants have reinforced our concerns regarding the sensitivity of the B&W plants to operational transients, we have concluded that continued operation of the B&W plants during the assessment does not pose a undue risk to the public health and safety.

Commissioner Asselstine adds:

The Commission's response indicates that a reassessment of B&W plants has been initiated. However, I have misgivings about the scope of the reassessment and the decision to give the B&W owners the lead in that reassessment.

Following the TMI accident in 1979, the NRC required the industry to reexamine many aspects of the B&W design, including the integrated control system and the auxiliary feedwater systems. The Davis-Besse and Rancho Seco events of 1985 illustrate that that industry reexamination did not lead to the necessary improvements to the B&W plants. The Commission, in essence, has said that the best approach to resolving the known design weaknesses and vulnerabilities in the B&W plants is to ask the industry once again to reexamine the plants. I do not agree. Although B&W and the utilities which operate B&W plants should be involved in the reassessment program, I do not believe that they should be given the leadership role in conducting the reassessment.

QUESTION 12. (Continued) - 4 -

Further, there appears to be some concern on the part of the ACRS with regard to the scope of the reexamination. In a July 16, 1986 letter from the Commission's Advisory Committee on Reactor Safeguards to the Commission's Executive Director for Operations, ACRS questions the scope and effectiveness of the B&W Owners Group review. According to the ACRS:

> At the time of our Subcommittee meeting the BWOG program's main emphasis seemed to be directed at improving plant on-line performance, rather than addressing the safety objectives of the NRC-B&W reassessment initiative. Our review of this program indicates that it may lead to improved plant on-line performance; however, we are concerned that plant safety does not appear to be its central focus. We believe it should be. While it is true that improved plant performance could represent safer operation, that is not an inescapable outcome.

The ACRS letter raises several specific concerns regarding the B&W Owners Group program, including the fact that apparently little attention is being given to decay heat removal despite the importance of decay heat removal in ensuring public protection. I am particularly disturbed by the fact that we are identifying potentially significant deficiencies in the B&W Owners Group review after six months have elapsed in this one-year effort. I believe that the concerns identified by the ACRS are further evidence that giving the lead role to the industry in this reassessment of the safety of the B&W design was ill-advised. I believe that an independent review of the B&W design, as I proposed last year following the June 9, 1985 operating event at the Davis-Besse plant, would be more useful.

Finally, I disagree with the Commission's stated conclusion that because the Davis-Besse and Rancho Seco events had little or no offsite consequences, they did not pose an undue risk to the public health and safety. In my view, both events disclosed examples of past management practices which resulted in a significant deterioration in equipment condition and reliability, and in poor operations performance. These management breakdowns have resulted in extended plant shutdowns at both plants and in extensive improvement programs which are aimed at correcting the many consequences of the management failures at these plants. In my view, the management breakdowns at these plants and the resulting deterioration in plant safety systems reliability and operations performance posed an undue risk to the public health and safety by creating the potential for a much more serious accident.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, D. C. 20555

July 16, 1986

Mr. Victor Stello, Jr.
Executive Director for Operations
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr. Stello:

SUBJECT: ACRS COMMENTS ON THE BABCOCK & WILCOX (B&W) OWNERS GROUP SAFETY AND PERFORMANCE IMPROVEMENT PROGRAM

During its 315th meeting, July 10-12, 1986, the Advisory Committee on Reactor Safeguards discussed the B&W Owners Group Safety and Performance Improvement Program. The ACRS Subcommittee on Babcock & Wilcox Reactor Plants met in Washington, D.C. on June 25, 1986 to discuss the program. The Subcommittee had the benefit of discussions with representatives and consultants of the B&W Owners Group (BWOG) and the NRC Staff. We also had the benefit of the documents listed.

Recent events at some B&W plants have resulted in increased NRC concern regarding the frequency of reactor trips and complexity of the transients in B&W plants. These concerns have led the NRC Commissioners and the Staff to call for a broad reassessment of B&W plants to assure that they provide acceptable levels of safety. At the request of the Staff, the BWOG has taken a lead role in performing the reassessment.

At the time of our Subcommittee meeting the BWOG program's main emphasis seemed to be directed at improving plant on-line performance, rather than addressing the safety objectives of the NRC-B&W reassessment initiative. Our review of this program indicates that it may lead to improved plant on-line performance; however, we are concerned that plant safety does not appear to be its central focus. We believe it should be. While it is true that improved plant performance could represent safer operation, that is not an inescapable outcome.

We offer the following additional observations and recommendations:

1. An examination of the operating history of B&W plants indicates that three B&W plants, operated by one utility, have operated with little cause for concern. The incidents that have produced concerns have occurred at plants operated by several other utilities. It seems logical, in seeking root causes of substandard performance, to look at the effect of operating organizations on system performance, rather than concentrating entirely on system design.

2. There is the observation, primarily from analysis but partially confirmed by experience, that B&W systems respond differently, perhaps less favorably, to upsets than do the pressurized water

reactor (PWR) plants with Combustion Engineering or Westinghouse reactor systems. This should not be surprising -- they were designed to respond differently. The once-through steam generator, the integrated control system, and different piping arrangements and auxiliary capacities give a nuclear steam supply system that is more quickly responsive to load changes and other external challenges than the other PWRs. Whether, from the perspective of safety, this is good, bad, or indifferent is not yet clear. The NRC Staff and the BWOG should focus on this observation and come to an engineering determination as to its significance.

3. We are concerned that apparently little attention is being given to decay heat removal. We note that, even given a complex transient, if the ability to trip the reactor and remove decay heat is preserved the ability to protect the public is ensured.

We expect to meet again with the BWOG and the NRC Staff to continue discussions.

Sincerely,

David A. Ward
Chairman

References:
1. B&W Owners Group Trip Reduction and Transient Response Improvements Program, BAW-1919, Revision 00, May 1986
2. Letter from D. Crutchfield, NRC, to H. Tucker, BWOG, Subject: B&W Design Reassessment, dated June 2, 1986
3. Letter from H. B. Tucker, BWOG, to C. Wylie, ACRS, Subject: B&W Owners Group Safety and Performance Improvement Program, dated July 10, 1986

QUESTION 13. What are the main safety issues that you believe might have to be revisited in the U.S. as a result of "lessons learned" from Chernobyl?

ANSWER.

See response to question number 2.

**Department of Energy**
Washington, DC 20585

July 17, 1986

Honorable James A. McClure
Chairman, Committee on Energy
and Natural Resources
United States Senate
Washington, D.C. 20510

Dear Mr. Chairman:

On June 19, 1986, Mary L. Walker, Assistant Secretary for Environment, Safety, and Health, and Delbert Bunch, Principal Deputy Secretary for Reactor Deployment, appeared before your Committee to discuss the effects of the Chernobyl accident on the U.S. nuclear industry.

Following that hearing, you submitted written questions for our response to supplement the record. Enclosed are the answers to those questions, which also have been sent directly to the Committee staff.

If you have any questions, please have your staff call Mike Gilmore or Cathy Hamilton on 252-4277. They will be happy to assist.

Sincerely,

Robert G. Rabben
Assistant General Counsel
for Legislation

Enclosure

POST-HEARING QUESTIONS AND ANSWERS

RELATING TO THE

JUNE 19, 1986, HEARING

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES

UNITED STATES SENATE

WITNESSES: MARY L. WALKER
ASSISTANT SECRETARY FOR ENVIRONMENT, SAFETY, AND HEALTH

AND

DELBERT F. BUNCH
PRINCIPAL DEPUTY ASSISTANT SECRETARY FOR REACTOR DEPLOYMENT

## QUESTIONS FROM CHAIRMAN JAMES A. MCCLURE

Question 1: Even though DOE's review of the N-reactor in Hanford revealed no significant safety deficiencies, I recall that the review team did make a number of recommendations for improvements to the plant in certain areas. Could you elaborate on these recommendations? Who will decide if and when to make these improvements? Will the Office of Environment, Safety, and Health oversee this activity?

Answer: The Special Safety Review by ES&H which looked at the N-Reactor with respect to graphite fire protection and the adequacy of the reactor's confinement system was completed and the report was released on May 19. That review had the following recommendations.

Fire Protection for Graphite Moderator

Although the Team concluded that postulated accident scenarios leading to dangerous mixtures of combustible gases were not credible, it recommended that the reliability and availability of the inert gas monitoring system, as a safety-related system, be reevaluated and new technical specifications be established, as necessary, to reflect the value of the system in the fire/explosion protection of the reactor. The Team further recommended that hydrogen levels in the inert gas be monitored to further strengthen the present gas monitoring system.

Confinement System

The Team recommended that the probabilistic risk assessment (PRA) that has been initiated should be used to verify that challenges to the confinement have been comprehensively encompassed, and, once completed, the PRA should be maintained current. Computer models of the accidents that form the confinement system design bases should continue to be maintained current and should be based on current probabilistic risk assessments.

The Team further recommended, in the interest of further assuring the expected performance of the steam vent valves under accident conditions, verification testing should be conducted of a vent valve to determine the effect of the wet steam release on its subsequent closure and seal tightness.

The Department of Energy (DOE) has a number of additional N-Reactor reviews that are ongoing which will lead to numerous recommendations for improvement. These reviews include:

- A Technical Safety Appraisal by ES&H of the reactor operation.
- A design review by ES&H of the adequacy of the plant's safety features.
- A review by a panel of experts on the design of N-Reactor in light of the Chernobyl accident.
- A safety review by the National Academies of Sciences and Engineering of all of DOE's Category A reactors (N-Reactor included) in light of the Chernobyl accident.

DOE line management responsible for the N-Reactor will address all recommendations and proceed with an orderly program of implementation. The Office of the Assistant Secretary for Environment, Safety, and Health will track the Department's progress on the recommendations until they can be closed out.

## QUESTIONS FROM CHAIRMAN JAMES A.MCCLURE

Question 2a: If DOE's production reactors had to be shutdown for any length of time for whatever safety improvement might come out of the Chernobyl "lessons learned", what impact would this have in terms of national security?

Answer: The Nation's nuclear deterrent is critically dependent upon the continued operation of the existing defense production reactors. An unscheduled prolonged outage may begin to impact the availability of the necessary quantities of nuclear material required to support the Nation's nuclear weapons stockpile.

QUESTIONS FROM CHAIRMAN JAMES A. MCCLURE

Question 2b: Does the Department have any plans to revisit its 1983 proposal to build one or more New Production Reactors?

Answer: The Department of Energy decision to deploy a New Production Reactor (NPR) has been deferred until completion of life extension studies for the existing Savannah River Plant production reactors and refurbishment plans for the N Reactor are finalized and requirements for material production confirm the need for an NPR.

QUESTIONS FROM CHAIRMAN JAMES A. MCCLURE

Question 4: You state that the confinement systems at DOE's production reactors meet federal requirements for protecting the public. Whose federal requirements are you referring to? How do these compare with NRC's requirements?

Answer: The existing confinement systems for the Department of Energy production reactors were selected and designed as the most appropriate method of reducing radionuclide releases in the event of an accident and assuring that doses at the boundry and beyond are within DOE requirements. These requirements cite Nuclear Regulatory Commission regulations found at 10 CFR Part 100.

QUESTIONS FROM CHAIRMAN JAMES A. MCCLURE

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| Question 3: | How much would it cost to upgrade the confinement systems at Savannah River to make these systems perform more like containment systems? |
| Answer: | As part of its ongoing program to assure the safe operation of its reactors, the Department investigated the cost and benefits of constructing containment structures. The modification of the four Savannah River Plant reactors and the N Reactor at the Hanford site from confinement to containment would be physically feasible, but would clearly be an extremely difficult job costing from \$3-\$5 billion and requiring 3-4 years of construction time. The job would require strengthening and lining of the building walls, sealing or providing automatic shutoffs for all building penetrations, relocating some equipment and systems, and providing new systems where necessary. All of these new and existing systems would have to be examined and analyzed in detail for compatibility with existing systems to ensure a total system operation. The addition of containment would provide only a small improvement in the protection of the public, would not significantly increase the overall safety of the reactors and would therefore, not be a cost effective improvement to public safety. |

QUESTIONS FROM CHAIRMAN JAMES A. MCCLURE

Question 5: DOE laboratories have carried out most of the safety research programs managed by both the NRC and the DOE. What has been the budget profile for safety research at these two agencies over the last four years?

Answer: The NRC research budget for the last 4 years is tabulated below.

($ in Millions)

| FY 1983 | FY 1984 | FY 1985 | FY 1986 |
|---|---|---|---|
| $189.3 | $173.0 | $132.5 | $109.2 |

The DOE safety budget viewed in a broad sense includes light water reactor (LWR), liquid metal reactor (LMR), and high temperature gas reactor (HTGR) safety research conducted by the DOE Office of Nuclear Energy as well as portions of programs in the DOE Offices of Energy Research and Environment, Safety, and Health.

The Office of Nuclear Energy LWR safety budget over the last 4 years has been:

($ in Millions)

| | FY 1983 | FY 1984 | FY 1985 | FY 1986 |
|---|---|---|---|---|
| LWR | $15.0 | $22.0 | $31.3 | $27.9 |

Answer 5
(continued): The LWR work consisted mainly of tests on the Loss-of-Fluid-Test (LOFT), Three Mile Island (TMI) research and development, and advanced LWR concepts that will provide for safety improvements. In the LMR and HTGR areas, a comparable number would be $14.8 million for safety aspects of advanced reactors and related safety research and development as well as $46.0 million for operation of the Transient Reactor Test (TREAT) facility.

The DOE Office of Energy Research budget for conducting research on the biological health effects from radiation has averaged approximately $39.0 million in each of the last 4 fiscal years.

The oversight functions and activities assigned to the DOE Office of Environment, Safety, and Health have been budgeted at nearly $17.0 million for fiscal years 1985 and 1986 and includes work on earthquake protection, health physics and dosimetry, and emergency preparedness.

## QUESTIONS FROM CHAIRMAN JAMES A. MCCLURE

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| Question 6: | NRC's nuclear safety research budget has dropped substantially over the last several years. Has DOE's budget increased to take up the slack? Does DOE have any plans underway to build up its generic safety research capabilities to take over where NRC left off? |
| Answer: | The DOE Light Water Reactor (LWR) research program has not, in general, taken over work that was dropped by the Nuclear Regulatory Commission (NRC) because of cuts in the NRC budget. This is due in part to the fact that some of their work in our view was not focused on resolution of high priority issues and in part due to the differences in scope of NRC programs as compared with DOE programs. The thrust of DOE's LWR safety research is primarily directed towards reactors for the future. Given the strong relationships between NRC, industry and DOE programs, the Department will continue to closely coordinate its programs with those of the NRC to maximize use of the available R&D resources. |

QUESTION FROM CHAIRMAN JAMES A. MCCLURE

Question 7: In terms of safety research facilities at DOE labs, do we have the same capabilities that we had back in 1979 when DOE was called upon in response to TMI? Please describe what DOE actually has done over the last 7 years to address the TMI accident.

Answer: The DOE labs now have fewer large facilities for performing safety research than they had in 1979, as indicated in the response to Question 8. Immediately following the TMI-2 accident, both the Semiscale and Loss-of-Fluid-Test (LOFT) facilities were used to understand the accident scenario and over the subsequent 7 year period many experiments were performed on both facilities to study the full spectrum of small breaks and transients whose importance was highlighted by TMI-2. The DOE ran an international consortium of countries to fund the LOFT experiments over the past 3 years, and the final experiment in this series was particularly important to the understanding of TMI.

The DOE has also funded a TMI-2 program which has developed a substantial amount of information in areas of fuel and waste handling, cleanup from a severe accident, and accident evaluation. Information from this program is shared with industry and government agencies both domestically and internationally. DOE has provided the technology to handle the accident wastes and to remove the damaged core, has taken

Answer 7 (continued): possession of the wastes, and is removing the core debris from TMI.

More broadly, DOE has funded research in the areas of source term and severe accident research, and is currently funding research on fission product transport, deposition and revolatization and on core melt progression. Work has also been conducted on improved safety systems, ones that would provide additional capabilities to withstand the event that took place at TMI-2. This research is coordinated with that of NRC and focused on the non-regulatory interests of industry.

QUESTIONS FROM CHAIRMAN JAMES A. MCCLURE

Question 8: Of the safety research facilities at the Idaho National Engineering Laboratory, which are still operating? Which are on standby? Which are permanently shutdown? Was the decision to shutdown these facilities based on budgetary considerations or on the lack of need for further safety research? Could we reactivate these facilities if needed? In what time-period? At what cost?

Answer: None of the following six safety research facilities at the Idaho National Engineering Laboratory (INEL) are operating.

The Power Burst Facility (PBF), most recently used for severe accident and source term research, is on a standby status, due to NRC budgetary constraints. NRC concluded that the information obtained from other facilities, while not as good as that from the PBF, was justified based on cost-benefit considerations. It could be reactivated in 12 weeks at a cost of $500,000 and operated for $6.5 million per year plus the cost of fuel trains and analysis.

The Loss-of-Fuel Test Facility (LOFT), used for large scale reactor system accident simulation, was permanently shut down this spring. The cost of facility operation compared to the value of experimental results was not favorable for continued operation of this reactor. The LOFT reactor has been removed from the containment/control room complex and cannot be reused. The building complex is now in a decontaminated state.

Answer 8 (continued):

The Semiscale Facility, used for reactor system thermal hydraulic studies, was shut down due to NRC budgetary constraints. It could be reactivated in 28 weeks and operated for $4.0 million per year plus the cost of any special modifications and analysis.

The Two-Phase Loop, used for two-phase water hydraulic studies, was shut down due to budgetary constraints. It could be reactivated in 26 weeks at a cost of $1.0 million.

The Air Water Loop, used to simulate two-phase water flow conditions for instrumentation calibration, was shut down due to budgetary constraints. It could be reactivated in 16 weeks at a cost of $70,000.

The Blowdown Loop, used for high pressure two-phase transient calibration of instruments for the PBF and LOFT, was tied to operation of these facilities.

However, the Experimental Breeder Reactor II (EBR-II), the Transient Reactor Test (TREAT) Facility, and the Zero Power Plutonium Reactor (ZPPR) are operational and being utilized for safety research and other activities in support of advanced concepts.

QUESTION FROM CHAIRMAN JAMES A. MCCLURE

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| Question 9: | Is there more work that could and should be done to resolve uncertainties associated with the source term issue? What kinds of research are still needed? Do we have the facilities to do such research? Has NRC or DOE proposed such research in their FY 1987 budget request? |
| Answer: | There are several areas of research that could be conducted to resolve uncertainties associated with the source term issue. These include deposition and revaporization of various radioactive species; transport of various fission products through pipes, rooms, and buildings in the presence of various aerosols; high pressure core melt ejection; core-concrete interaction; core melt progression and hydrogen generation; hydrogen combustion; containment failure mode and timing; and computer code assessment and validation. The degree to which uncertainties must be resolved, however, depends upon the use to which the source term data is being applied. For example, prior to Chernobyl, there was growing consensus that the remaining uncertainties in the source term were not so large, so that sheltering as opposed to evacuation would be an appropriate response in implementing the emergency response plan for some reactor types. On the other hand, more work to reduce uncertainties would be necessary to establish new siting criteria. |

Answer 9
(continued):

The facilities exist in DOE laboratories to do most of this research with the exceptions of large scale containment studies and integral-system fission product release and transport, which can be done in foreign laboratories where the United States has close relations. In the FY 1987 budget request, DOE has proposed $6 million and NRC $19 million worth of work relevant to the issues listed above.

QUESTIONS FROM CHAIRMAN JAMES A. MCCLURE

Question 10: You have been involved in the emergency response exercise at the Shoreham plant in Long Island. The state and local officials still refuse to participate in these drills. Some people perceive the problem as being that of evacuating the entire Long Island population -- a problem that even I would admit to being difficult at best. Could you estimate what the actual population density is in a 10-mile radius of Shoreham? How about a 20-mile radius? 30-miles? How about populations surrounding the Seabrook or the Shearon Harris plants where similar problems exist in terms of state and local refusal to cooperate?

Answer: The Nuclear Regulatory Commission (NRC) at 10 CFR 50.47(c)(2) prescribes two emergency planning zones (EPZ's) for licensing purposes--a plume exposure pathway of about 10 miles in radius from the plant and an ingestion pathway of about 50 miles in radius from the plant. The exact size and configuration of these EPZ's is determined by local emergency response needs and capabilities as they are affected by such conditions as demography, topography, land characteristics, access routes, and jurisdictional boundaries. Any protective action portion of an emergency response plan, including evacuation, only applies to the 10-mile EPZ.

Based on utility figures supplied to the Federal Emergency Management Agency and NRC, the approximate population in the 10-mile EPZ for Shoreham is 139,000 in winter and 160,000 in summer; Seabrook, 147,000 in winter and 287,000 in summer; and Shearon Harris, 23,000. (We could find no figures for

Answer 10 (continued): the population within a 20- or 30-mile radius of these facilities.)

Regarding Shoreham, on August 26, 1985, the NRC Atomic Safety and Licensing Board held that there is no "finding that there is anything unique about the demography, topography, access routes, or jurisdictional boundaries in the area in which Shoreham is located ... the reactor fails to reveal any basis to conclude that it would be impossible to fashion and implement an effective offsite plant for the Shoreham site." Thus, it is clear that a good, workable emergency response plan--including provisions dealing with evacuation--exists for the Shoreham facility. It is unfortunate that some people have confused the Shoreham emergency response plan with the evacuation of the entire population of Long Island.

QUESTIONS FROM CHAIRMAN JAMES A. MCCLURE

Question 11: Do you think our reactor-containment or confinement systems (for commercial or defense production reactors) would be able to withstand an explosion of the magnitude experienced at Chernobyl?

Answer: The information pertaining to the Chernobyl incident is not yet detailed enough to draw a clear picture of what actually happened nor the extent and power of the "explosion." Until such information is available, it is not possible to speculate on the ramifications of a similar event on our commercial or defense production reactors.

QUESTION FROM CHAIRMAN JAMES A. MCCLURE

Question 12: Is there room for improvements in U.S. reactor containment or confinement systems? Could you give us some examples? Where are the major deficiencies in current containment systems used in the U.S.?

Answer: Various changes to containment or confinement systems have been proposed. For example, in PWR plants, some are advocating changing a standard containment system to a filtered-vented containment system. In BWR plants, NRC has proposed four possible changes: hydrogen control for Mark III systems, containment dry well sprays, provisions for wet well venting, and inclusion of refractory materials to direct debris material so as to avoid by-pass of the suppression pool. But whether such changes are improvements depends on several factors; such as, does a current containment provide a sufficient level of safety; is a slight improvement in safety worthwhile if the cost of the improvement is very significant; to what degree is added protection against extremely low probability events worthwhile if accidents with less severe consequences are made more probable? Reviews on the adequacy of containment structures are being made in conjunction with the NRC/DOE/industry review of the severe accident/source term issue. Whether there are deficiencies that will need correction with be identified as part of this work.

Answer 12
(continued): Work is also underway by the industry/EPRI and DOE on advanced light water reactors. This work, especially that related to smaller-sized LWR plants, will provide additional opportunities for improved containment systems since they are still in the design stage.

QUESTION FROM CHAIRMAN JAMES A. MCCLURE

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|---|---|
| Question 13: | You have submitted to Congress legislation to reform the licensing process for building nuclear power plants. In your opinion, does the Chernobyl accident make this legislation any less attractive now than it was before? |
| Answer: | No, it makes it not only more attractive but imperative. The Chernobyl accident should serve as a reminder of the recommendations which were made by the President's Commission in the wake of Three Mile Island (TMI) that in order to prevent another accident as serious as TMI, fundamental changes are needed in the regulatory process. That was over 5 years ago and as of yet those recommendations have not been implemented although they are clearly in the public and national interest. Chernobyl should serve as a catalyst for action now, not as an excuse for further procrastination. |

QUESTION FROM CHAIRMAN JAMES A. MCCLURE

Question 14: Would you agree that the current licensing process simply doesn't work, in terms of bringing a safe plant on-line in a reasonable period of time while allowing for meaningful public participation. How would DOE's proposal for licensing reform fix the current problems? How would licensing reform affect public health and safety?

Answer: Yes, we agree that the current nuclear licensing process is fundamentally flawed. The current design-as-you-go, regulate-as-you-go process results in delaying key safety decisions until construction is well underway, or in some cases, until the plant construction is complete. The Department's legislative proposal would result in the early resolution of all major safety issues based upon essentially complete design and site information. The public's participation would be more effective since it would be both early in the process and based upon more complete information. With respect to public health and safety, the Department's proposal would enhance public health and safety by:

1. Focusing design, construction, operating and regulatory activities on a few standard designs with which organizations, institutions, and personnel would become familiar and, therefore, more competent.

Answer 14
(continued):

2. Early resolution of all major safety issues in the basic plant design resulting in fewer backfits which are normally not only more expensive, but less effective.

3. Insure that any backfits that are required do, in fact, enhance overall plant safety.

4. Encourages industry to develop standardized, advanced LWR plant designs which will be safer than the current operating plants and for which transfer of construction and operating experience from one plant to the next will be possible.

## QUESTIONS FROM CHAIRMAN JAMES A. MCCLURE

Question 15: Explain how next generation plants could further improve the safety and licensability of nuclear powerplants in this country. What is DOE doing in terms of research on next generation plants? Is the industry participating? Are utilities interested? What has DOE's budget profile looked like for FY's 84-87, with respect to research in High Temperature Gas Reactors and Liquid Metal Cooled Reactors?

Answer: Advanced reactors are under development. Concepts have been identified which have the potential for producing reliable, low-cost power and improved safety. Each of the advanced concepts--including advanced light water reactors (ALWR's), liquid metal reactors (LMR's), and high temperature gas reactors (HTGR's)--plan on certification of their respective plant designs by the Nuclear Regulatory Commission (NRC), so future commercial applications would require addressing only site-specific licensing issues.

In FY 1986, DOE initiated an Advanced Light Water Reactor (ALWR) Technology program (coordinated with the Electric Power Research Institute/utility industry ALWR program) directed toward the availability of substantially improved ALWR plant designs for the mid-1990's. The program is based on cost-sharing with the performing industrial contractors who were selected through competitive solicitation. The program includes substantive technology development, design

Answer 15 (continued): verification of large ALWR plant designs leading to NRC design certification, and mid-size (about 600 MWe) Advanced Boiling Water Reactor and Advanced Pressurized Water Reactor plant design technology development.

For the LMR and HTGR modular designs, DOE is providing base technology support in the areas of fuel cycle development and demonstration, licensing support, and feature testing of critical components and systems. DOE has prime contracts in place with General Electric, Rockwell International, and General Atomics for the conceptual design of passively safe, economically competitive LMR and HTGR plant modules. The LMR design contracts with General Electric and Rockwell International include cost sharing. All of the advanced concepts design programs have advisory boards composed of utility members who work closely with the design teams Supporting work is also in progress at DOE national laboratories.

The DOE budget profile for fiscal years 1984-1987 for the LMR and HTGR overall programs is tabulated below.

($ in Millions)

| | B/O FY 1984 | B/O FY 1985 | B/A FY 1986 | B/A FY 1987 |
|---|---|---|---|---|
| LMFBR/LMR | $362.3 | $260.4 | $228.3 | $166.0 |
| HTGR | $29.8 | $31.8 | $30.6 | $5.3 |

QUESTIONS FROM CHAIRMAN JAMES A. MCCLURE

Question 16: Will the technology for next generation plants be sufficiently developed to offer a plant when one is most urgently needed by utilities -- say, by the mid 1990's?

Answer: Current design and technology support schedules are directed to an advanced prototype operating module by the mid- to late-1990's. The general base technology for the next generation Liquid Metal Reactor (LMR) and High Temperature Gas Reactor (HTGR) is in place to support their commercial introduction in the first part of the next century. The areas of technology where research and development is being concentrated are fuel cycle development and demonstration, licensing support, and feature testing of critical components and systems. This support is essential to the development, construction, and testing of advanced prototype systems in the 1990's that must precede commercialization.

Certification of advanced, large-sized light water reactors (LWR's) by the Nuclear Regulatory Commission for the early 1990's is proceeding based on a cooperative effort among vendors, the Electric Power Research Institute, and the Department of Energy. Certification of these advanced LWR plants are based on significant technology development from currently operating plants and an extensive cooperative design and development effort with Japanese utilities.

Answer 16 (continued): Design development and testing is also underway for smaller advanced LWR's leading to their availability by the mid-1990's.

## QUESTIONS FROM CHAIRMAN JAMES A. MCCLURE

Question 17: Please describe the loss-of-power and loss-of-heat-sink tests that were recently performed at EBR-II. Would you say that this demonstrates the walk-away safety and total forgivingness of a liquid metal cooled plant that uses metal fuel? What other aspects of a liquid metal-cooled reactor tend to make it much easier to operate than, say, a light water reactor?

Answer: The Department's Civilian Reactor Research and Development Program is directed at the development of nuclear powerplants that are passively safe, less costly and simpler to construct and operate.

Two successful tests were conducted on April 3, 1986, at the Experimental Breeder Reactor II (EBR-II); these tests represent a major achievement in the development of future plants. The purpose of the tests was to demonstrate the self-shutdown characteristics of a Liquid Metal Reactor (LMR) for highly abnormal events without need for human intervention or the operation of active engineered components such as control rods and pumps.

The starting point was identical for both tests with the reactor at full power and the control system temporarily disabled to hold the control rods at the full-power setting. In the loss-of-power test, power was shut off to all primary and secondary coolant pumps simulating a station blackout while leaving the reactor running at full power without

Answer 17 (continued): forced cooling. As predicted, the fuel and sodium coolant temperatures initially increased until the combined effects of thermal expansion and natural coolant circulation shut the reactor down.

In the loss-of-heat-sink test, power to the secondary cooling system was turned off while the reactor continued operating. Again, the reactor shutdown without operator action as a result of the self-generated negative reactivity feedback characteristics of the system. Further analyses and confirmatory testing will be conducted to assure that operator action, if attempted, could not defeat the safe, inherent self-shutdown capability of the system. The strong negative reactivity feedback exhibited in these tests are due to a combination of the high heat conductivity of the metal fuel and the thermal inertia of the large volume of pool sodium in the EBR-II.

Advanced LMR's being developed by DOE are utilizing these features. Work is also continuing in support of these advanced concepts to develop an improved metal fuel and to demonstrate new, simpler processes for the metal fuel cycle. The EBR-II tests demonstrated that liquid metal reactors can be designed to be self-regulating in protecting operators, the public, and the financial investment. The properties

Answer 17 (continued): of liquid metal combined with the passive self-regulating features of the core response offer the potential for simpler reactor systems. In turn, reactor simplicity leads to easier operations and maintenance. All advanced reactor designs are striving for simpler systems; however, independent of the reactor type, skilled and highly trained personnel are essential to assure safe and reliable operations.

POST-HEARING QUESTIONS AND ANSWERS

RELATING TO THE

JUNE 19, 1986 HEARING
BEFORE THE
SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES
WITNESS: ASSISTANT SECRETARY MARY L. WALKER

QUESTIONS SUBMITTED BY: SENATOR METZENBAUM

QUESTIONS FROM SENATOR METZENBAUM

Question 1: DOE reactors do not have containments, but are housed in buildings called confinements.

a. Could the confinements withstand the pressures of a hydrogen explosion?

b. Are DOE reactors subject to NRC safety standards?

c. Could all DOE reactors meet all NRC safety standards?

Answer: a. The DOE Category A research and production reactors (those over 20 MWt) include a number of unique designs with different safety systems. These systems are designed to assure that risks of accidents are very low and prevent large scale hydrogen generation and limit releases to 10 CFR Part 100 values. Some reactors have confinement systems which sweep away the hydrogen as it is generated, thus preventing an accumulation which could explode. The ability of a containment or a confinement system to withstand the effects of a hydrogen explosion will depend on the size of the explosion and the strength of the building. Some of DOE's reactors, in particular the large production reactors, have confinement buildings and biological shields that are very massive (reinforced concrete walls and roofs that are several feet thick) which could withstand a sizeable explosion. The Department has a series of ongoing reviews at the N Reactor at Richland, Washington, which are considering the reactor's safety in light of the Chernobyl accident. The conclusions to date indicate that the N Reactor is well protected from the dangers of a Chernobyl-type accident.

b. By legislation, existing DOE reactors are exempt from NRC licensing; however, DOE policy states that nuclear facilities will meet standards, guides, and codes that are applied to comparable licensed facilities. Exceptions are granted only when the proposed alternative is judged by DOE to provide equivalent or better protection, or when the NRC requirement is clearly not applicable.

c. All DOE reactors did meet all NRC, or its predecessor agency, safety standards when they were built; however, not all DOE reactors could meet all NRC safety standards now. The majority of DOE reactors were designed and built over 25 years ago, and many current NRC standards did not exist at that time. Backfitting at DOE facilities, where practical, has been performed to minimize the differences between earlier and later plants. The DOE nuclear facilities are continually being upgraded to meet the intent of new and revised standards and lessons learned from accidents and incidents such as TMI-II, the Browns Ferry fire, etc.

Question 2: Please estimate the costs of damages from a Chernobyl-type accident (i.e., core melt and escape of radiation into the atmosphere) at the Hanford facility and the Savannah River Plant, which required emergency evacuation up to an 18 mile radius.

Answer: It is really not possible to estimate the cost of damages due to a Chernobyl-type accident at Hanford or Savannah River. The principal uncertainties are the percentage of radioactivity that would be released from the facility and the atmospheric conditions that would determine the location and extent of fallout. Even at this late date the total cost of the TMI accident is not known.

The replacement cost for one of the DOE production reactors would be several billion dollars and this could dominate all otner costs. The "burial" costs of the facility might be several hundred million dollars. The other costs, compensation for loss of life and injury, decontamination of areas, crop and farm animal losses, and interdiction of property depend upon the nature of the incident and the atmospheric conditions. We have no basis for estimating these costs.

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| Question 3: | Has the DOE designed, with the cooperation of the appropriate State and local governments, evacuation plans for civilian populations near all of its nuclear facilities? |
| Answer: | Yes. All DOE facilities have sheltering and evacuation plans which were developed in close coordination with State and local governments and their emergency plans. Frequent tests are conducted to assure that these plans are effective. Hanford and Savannah River also are participants in the emergency plans for NRC licensed reactors; WPPSS-2, located within the Hanford reservation, and Vogtle (Georgia Power Co.), where almost half of the 10 mile emergency planning zone is occupied by the Savannah River Plant. |

| | |
|---|---|
| Question 4: | In designing evacuation plans, how large is the emergency planning zone used by the DOE? |
| Answer: | The emergency planning zones (EPZ) for DOE reactors vary considerably depending on the size, type, and location of the reactor. The larger production reactors at Hanford and Savannah River have EPZs equivalent to the 10 miles required for licensed power reactors. Rather than adopting an arbitrary distance, DOE's EPZs are based on realistic accident sequences and consequences, using a dose criteria of 5 rem whole body and 25 rem thyroid which is derived from the EPA protective action guides which are also used by the NRC and FEMA. |

JAMES A. McCLURE, IDAHO, CHAIRMAN

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United States Senate
COMMITTEE ON
ENERGY AND NATURAL RESOURCES
WASHINGTON, DC 20510

June 30, 1986

Miss Mary Walker
Assistant Secretary
Environment, Safety, and Health
U. S. Department of Energy
Washington, D.C. 20585

Dear Miss Walker:

On Thursday, June 19, 1986, you appeared before the Senate Committee on Energy and Natural Resources to present testimony on the Chernobyl Accident and Implications for Domestic Nuclear Industry. As a follow-up to this hearing, I would like to request that you provide written responses to the attached questions from my colleague, Senator Metzenbaum.

In order that this information can be made part of the hearing record, I must receive your written responses by no later than Thursday, July 10, 1986. If you have any questions on the matter, please call Marilyn Meigs or K.P. Lau of the Committee staff at 202-224-4431.

Your participation in this hearing is greatly appreciated.

Sincerely,

Jim McClure

James A. McClure
Chairman

Attachment

QUESTIONS FOR ASSISTANT SECRETARY MARY WALKER, DOE (Sen. Metzenbaum

1. DOE reactors do not have containments, but are housed in buildings called confinements.

Could the confinements withstand the pressures of a hydrogen explosion?

Are DOE reactors subject to NRC safety standards?

Could all DOE reactors meet all NRC safety standards?

2. Please estimate the costs of damages from a Chernobyl-type accident (i.e., core melt and escape of radiation into the atmosphere) at the Hanford facility and the Savannah river plant, which required emergency evacuation up to an 18 mile radius.

3. Has the DOE designed, with the cooperation of the appropriate state and local governments, evacuation plans for civilian populations near all of its nuclear facilities?

If such plans have not been developed for all DOE nuclear facilities, please list those facilities which do not have plans.

4. In designing evacuation plans, how large is the emergency planning zone used by the DOE?

**PROF. DR. RUDOLF SCHULTEN**
Direktor am Institut für Reaktorentwicklung der
KERNFORSCHUNGSANLAGE JÜLICH GmbH

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SENATE COMMITTEE ON
ENERGY AND NATURAL RESOURCES
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Senator James A. McClure
Chairman
United States Senate
Committee on Energy and Natural
Resources

Washington, DC 20510 / USA

Dear Sir:

Thank you very much for your letter dated June 25, 1986. Unfortunately I received it only yesterday on July 30th. Due to this it was not possible to make my responses available to you as you wished on July 9th. But I hope my answers are still of interest to you. Please find them in the attachement.

Sincerely,

Enclosure

Questions from Senator James A. McClure

1) After the accident at Chernobyl there was a great deal of intense contact between members of the Russian Embassy and German scientists. In particular, they enquired whether we could make available our knowledge on controlling the accident at Chernobyl. This especially involved extinguishing burning graphite.

   Furthermore, I am aware that the Nuclear Research Centre Karlsruhe provided information about the processes of core meltdown in the form of direct telephone conversations between Chernobyl and Karlsruhe.

2) I personally have not had any opportunity to meet engineers or operators from the Chernobyl nuclear power station or to hold discussions with them.

3) The actual accident in Chernobyl primarily consisted of the fact that a strong reaction between zirconium and steam as well as water occurred after a power excursion of the reactor due to overheating. A great deal of hydrogen developed as a consequence of this reaction and this led to at least one, perhaps even several, explosions severely damaging the reactor building. The evolution of heat during the reaction between zirconium and steam is extraordinarily great so that the graphite, at least in the first few days of accident progression, served as a heat sink and rather contributed to moderating the impacts. Only at a later point did surface ignition of the graphite occur, which apparently led to a slight burn-off of the graphite.

Questions from Senator Wallop

1) Euratom did not undertake any special activities in the days following the Chernobyl accident.

2) There were different reactions to the Chernobyl accident in the European countries. The most violent reactions were registered in the Federal Republic of Germany and in the Scandinavian countries, whereas the other countries did not experience such an intense reaction. Euratom did not have any integrating function for the European area in these discussions and reactions.

3) Euratom has not planned any discussions with the Soviet Union on reactor safety. On the contrary, the impulses for such discussions have been initiated by the IAEA in Vienna, and also by the Federal Republic of Germany at the proposal of Chancellor Kohl.

4) There is no agreement on an exchange of information concerning severe reactor accidents between the European Communities and the USSR. It is to be expected that negotiations on such obligations to provide information will be taken up at the IAEA negotiations timetabled for September in Vienna.

5) A strong antinuclear movement is currently under way in the Federal Republic. Its major objective is to prevent construction of the planned reprocessing facility at Wackersdorf. The appointment of Mr Wallmann as Minister of the Environment, Nature Conservation and Reactor Safety was generally welcomed in the Federal Republic. In future even more attention will undoubtedly be paid to reactor safety. No further resolutions on the construction of nuclear facilities are pending at the moment or for the next two years. I believe that during this period the Federal Government will form a more consolidated opinion about reactor safety. In my view the concept of passively inherently safe reactors will also be given considerable attention by the Federal Government.

6) I am not aware that any scientists from Euratom have visited the Chernobyl plant.

7) The role of graphite-moderated reactors has been intensively studied in the Federal Republic with respect to the Chernobyl accident. Expert opinion and official agencies have established that in Western reactors burning graphite cannot pose the same type of threat as in Chernobyl. The reason for this is that Western reactors are contained in prestressed concrete vessels protecting the reactor in all cases against the ingress of dangerous quantities of air.

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July 08, 1986

Senator James A. McClure
Chairman
Committee on Energy
and Natural Resources
Senator Dirksen Office Building
Room SD 360
United States Senate
Washington, D.C. 20510

Dear Senator McClure:

The response to the questions you asked in your letter of June 26, 1986, are forwarded herewith. I believe they include answers to the questions posed to me by Senator Domenici during the hearing on June 19, 1986.

Thank you for the opportunity to participate.

Sincerely,

John J. Taylor/bg

John J. Taylor
Vice President
Nuclear Power

JJT:bg

cc: Senator Domenici

JJT:3706AD6a

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| | |
|---|---|
| Question 1(a): | If U.S. plants were built in the future based on a more standardized technology, would that make EPRI's job easier with respect to analyzing safety features and responding to operational problems? |
| Answer: | Standardization can have many advantages in improving both safety and economics. If a large percentage of future plants are built based on a more standardized technology, it should make both government and industry responsibilities easier to carry out with respect to analyzing safety features and responding to operational problems. |
| Question 1(b): | Would standardization help in your ability to identify "lessons learned" from any specific plant incidents? |
| Answer: | Standardization probably would not help our ability to identify "lessons learned" from any specific plant incident; however, standardization would simplify the process of determining how the lessons learned should be applied to other plants. |
| Question 2: | Does the Chernobyl accident heighten the need in this country to resolve outstanding questions related to the source term issue for U.S. commerical plants? |
| Answer: | In our opinion, it will be a natural result of the Chernobyl accident to increase U.S. interest in source term related issues. This increased interest will auger for an acceleration of resolution of these issues. EPRI's source term program has for the last few years been among the highest priority programs in EPRI's Nuclear Power Division. This priority rating is an indication of our feeling of urgency in resolving source term related questions. The results to date give strong indication that the source term for U.S. light water reactors is substantially lower than presently used in regulation to estimate public risk and determine emergency planning requirements. The data available from Chernobyl to date has not changed our position. However, there is a possibility that data from the accident can be applied to further define the source term. Many factors pertaining to the accident must be considered carefully before any conclusions can be drawn. We may never know, for example, the energy |

release rates during the accident or the local meteorological conditions in the area during the accident. In summary, Chernobyl emphasizes the need for a thorough and realistic understanding of degraded core accidents, superior operator training and good emergency plans.

Question 3: Your written testimony describes in detail the differences between U.S. and Soviet "containment" systems. You summarize by saying that the Soviet system would not even qualify in the U.S. as a "containment" structure as we know it. So would you agree that news coverage of the Chernobyl reactor that alluded to a "containment" structure at Chernobyl was totally misleading and even downright incorrect?

Answer: I agree that certain news coverage of the Chernobyl reactor that alluded to a "containment" structure was misleading. A specific article in that category was carried in the New York Times on May 19. Three industry experts cited in the article wrote a letter to the New York Times stating that "the Chernobyl reactor has no containment in the sense we and other safety analysts in the U.S. use the word." A copy of their letter, as published in the New York Times on June 3, is attached.

Question 4(a): Would you say that, given the severe core damage (70% meltdown) that resulted from the TMI-2 accident, that we already have experienced the parallel "worst-case" accident that proves that Chernobyl-type consequences cannot happen in the U.S?

Answer: In a general probabilistic sense, the statement is true. However, to prove in the strict sense that a more serious accident cannot happen is such a restrictive criterion that if applied to all industrial activities would bring all activity to a halt. In fact, in the source term work mentioned in the response to Question 2, a more severe case is assumed of core melt down which penetrates the reactor vessel which still yields the lower source term cited.

Question 4(b): Would you say that, for the most part, we already incorporated any "lessons to be learned" from the Chernobyl accident when we made the numerous safety improvements that were imposed after the TMI-2 accident?

Answer: Yes. The lessons learned from the TMI-2 accident have led to changes that greatly reduce the chances of a severe core damage accident (melt down) in a U.S. reactor. TMI-2 certainly emphasized the importance of good containment. Even though the TMI-2 containment withstood a hydrogen fire, the TMI-2 accident revealed a weakness in protecting the integrity of some containment designs. This has led to modifications to improve hydrogen control in a severe accident. Chernobyl has simply re-emphasized the importance of hydrogen control. TMI-2 emphasized the importance of operator training and led to major improvements in operator training and operating personnel qualifications. Although we do not know the details yet of the Chernobyl accident, Soviet indications of operator error again re-emphasize this point. We are confident that no major loopholes remain in our approach to reactor safety.

I can say that these extremely important lessons and many others from both accidents have already been incorporated into our current thinking. We now go beyond the TMI lessons and continuously factor all safety concerns from observation or analysis into reactor design and operations. In our investigation of the RBMK-1000 design and the various possible accident scenarios, there is no evidence that would indicate an equivalent accident might happen to a U.S. commerical reactor. Our objective in investigating the Chernobyl accident is to make sure. As I stated in my testimony, a claim isn't being made that no lessons will be learned from Chernobyl but that we must wait to get the technical facts from the Soviets to ascertain any correct lessons.

Question 5: Could you provide to the Committee the details of the cancer studies done on the population in Hiroshima?

Answer: The details of the cancer studies done on the population at Hiroshima are voluminous. They result from a research effort of 40 years conducted by the Atomic Bomb Casualty Commission (ABCC) in cooperation with the Japanese National Institute of Health (JNIH) of the Ministry of Health and Welfare (JMHW) which is presently being pursued by the successor agency to ABCC, the Radiation Effects Research Foundation (RERF). ABCC was a research agency to the U.S. National Academy of Sciences (NAS) - National Research Council (NRC) and was supported by Contract AT-49-1-GEN-72 of the USAEC. Funding for the RERF continued study is by JMHW and by NAS/NRC with support from Contract Ex-76-C-28-3161 of the U.S. DOE. The address of RERF is 5-2 Hijiyama Park, Minami Ward, Hiroshima City 730, Japan.

Summaries of these detailed studies are contained in the following three papers:

1. Beebe, G., Land, C., and Kato, H. "The Hypothesis of Radiation-accelerated Aging and the Mortality of Japanese A-Bomb Survivors" Late Biological Effects of Ionizing Radiation, IAEA, Vienna, Vol. 1, pp 3-25, 1978. As cited in my testimony, this study of 295,000 survivors with excess radiation dosage revealed that of 14,000 cancer-related deaths, 415 were imputed from the excess radiation exposure.

2. Kato, H., and Schull, W.J. Studies of the Mortality of A-Bomb Survivors - 1950-1978: Part I "Cancer Mortality" Radiation Research Vol. 90, pp 395-432, 1982. This study of 284,000 survivors showed that of 11,000 cancer-related deaths, 526 were estimated to have been caused by the excess radiation exposure.

3. Schull, W.J. "Atomic Bomb Survivors: Patterns of Cancer Risk" in "Radiation Carcinogenesis: Epedemiology and Biological Significance" edited by Boice and Fraumani, Raven Press, 1984.

Question 6: Please comment on the news article that Senator Bumpers referred to, that states that 1985 was the worst year since Three Mile Island in terms of the nuclear industry's safety record.

Answer: The Annual Report from the NRC Office for Analysis and Evaluation of Operational Data (AEOD) states that there were fewer abnormal occurrences (AO) in 1985 than in 1984 and fewer on a per plant basis than in 1984 or 1983. AEOD considers the number of AOs per year as a reasonably constant index of the potential for serious occurrences. There is also a strong tendency for AOs to be most prevalent in plants licensed for less than 2 years. There are other ways to try to judge the relative annual operating effectiveness of nuclear plants. We see no apparent trend indicating 1985 as an unusually bad year for safety. During 1985 NRC investigated incidents at Davis Besse, Rancho Seco and San Onofre. Although none of the incidents investigated was a serious threat to the safety of the public, they did result in extended shutdowns to correct problems. AEOD states that those three incidents are a small sample and do not necessarily represent a trend in the industry safety record.

ES, *TUESDAY, JUNE 3, 1986*

NEW YORK TIMES

**Letters**

# Don't Let Chernobyl Cripple U.S. Nuclear Industry

To the Editor:

With regard to your May 19 front-page report that the Chernobyl nuclear reactor had more safety features and was closer to American design than was assumed immediately after the plant accident, we would like to make it clear that we are *not* among the "experts" who have changed our minds about the structure of the Chernobyl reactor. We have had accurate information and have been attempting to describe it to the public and the press.

The Chernobyl reactor has no containment in the sense we and other safety analysts in the U.S. use the word. In ordinary operation, the core and graphite moderator are confined behind barriers and covered by an inert nitrogen gas; but these barriers can be easily breached as they clearly were on April 26. The difference between confinement under favorable circumstances and containment under unfavorable ones is crucial.

In commercial U.S. reactors, there is a large, strong, tested containment structure designed to withstand the rise in pressure for days in case of accident. It should hold in the event of fire and station blackout, which appeared to be the problem at Chernobyl.

The Chernobyl reactor is of the RMBK 1,000 type, the most easily available drawing of which is for one built at Leningrad. But we recently learned that the accident at unit 4 at Chernobyl took place in a reactor where a pressure-suppression pool had been added under the reactor, as well as strong structure around the steam collectors and headers. This should reduce pressure rise in case one of the water pipes under the reactor breaks — one of the four most obvious accident scenarios. It seems to have played no part in the April 26 accident until cleanup, when the pool was emptied of water. The reactor core was not inside a strong containment, although there is a thick biological shield above the reactor. The building is not filled with inert gas, as are the containments of reactors such as Shoreham.

There are many lessons to be learned from this accident: the importance of containment and the danger of fire, both of which we already knew; the slowness of accident development, which allowed time for an unrehearsed, but orderly evacuation, and that even downwind in Sweden the effects were smaller than might have been feared. We want to find out exactly what happened and further insure that it was not a sequence of events that we have forgotten. We want to learn from the Russians their cleanup procedures, which we hope never to be forced to use firsthand.

It would be ironic if unreasonable fear caused us to cripple our nuclear electric capability as a result of this Russian accident, which caused us no harm and would not have occurred in the U.S.

**LINN DRAPER**
**EDWIN L. ZEBROSKI**
**RICHARD WILSON**
Cambridge, Mass., May 20, 1986

*The writers are, respectively, president of Gulf State Utilities; a nuclear scientist with Electric Power Research Institute, and a professor of physics at Harvard University.*

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## What the Figures Mean

To the Editor:

Your article on concern over Eastern European cancers as a result of the Chernobyl accident (May 16) quoted "tentative and highly inexact" estimates by Dr. Thomas B. Cochran and myself of the long-term health implications of radioactive pollution by the nuclear-plant accident.

We stressed that although the estimates of thousands of extra cancer deaths and tens of thousands of thyroid problems over the next decades seem large, the risk to any individuals other than those near the plant would be low. The large numbers are the result of adding very small individual risks over a very large population. This was not made explicit, and we are concerned that the article may feed rather than reduce the extraordinary fear of radioactivity from Chernobyl so evident in Europe.

Even 10,000 cancer deaths among a population of 100 million in Eastern Europe would raise the risk of cancer death of the average person by only about .05 percent, e.g., from 20 percent to 20.01 percent. The extra cancer deaths from Chernobyl will therefore be lost in the sea of cancer deaths that would have occurred in any case.

Douglas Florian

The increased incidence of nonfatal thyroid problems from inhalation and ingestion of radioactive iodine 131 is likely to be greater, but even if there are 100,000 extra thyroid cases, the average individual will have only one extra chance in 1,000 of developing a Chernobyl-induced thyroid problem.

Of course, the anonymity of most of the victims of Chernobyl does not make the accident any less of a disaster. Like the equally catastrophic chemical accident at Union Carbide's Bhopal plant, the Chernobyl accident tells us that we have to improve the designs of facilities containing such huge quantities of volatile toxic materials. This is why the reaction of the U.S. and Western European nuclear industries and their regulators, "It couldn't happen here," is so disturbing.

**FRANK VON HIPPEL**
Prof. of Public and International
Affairs, Princeton University
Princeton, N.J., May 17, 1986

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## Construction Problems

To the Editor:

An interesting article has come to light about conditions at the Chernobyl plant, published in the Ukrainian-language Literaturna Ukraina March 27, 1986, almost a month before the nuclear accident. The author, Lyubov Kovalevska, probably an engineer at Chernobyl, recited shortcomings, excerpts of which include:

"The time allocated for its construction was reduced from three years to two, and building work began in 1985 with minimal supplies . . . With the tightening of plans that were already tight, it turned out that no one was ready — neither the designers, nor the suppliers, nor the builders themselves . . . The low quality of design and costing documentation . . . caused additional labor expenditure and called for reworking, and great material and moral efforts . . . In a word, all the shortcomings of the building process, which are unfortunately typical, became acute and apparent . . . In 1985 some 45,500 cubic meters of prefabricated reinforced concrete was ordered; 3,200 were missing, and of the 42,300 cubic meters received, 6,000 were faulty."

A fuller quotation and discussion is in the May 14 issue of Soviet Analyst (London).

**ELLIOT R. GOODMAN**
Providence, R.I., May 23, 1986

*The writer is professor of political science at Brown University.*

OFFICIAL COMMITTEE FILE
PLEASE RETURN

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SENATE COMMITTEE ON
ENERGY AND NATURAL RESOURCES
RECEIVED
JUL 23 1986
WASHINGTON, D.C. 20510

July 18, 1986

The Honorable James A. McClure
Chairman
United States Senate
Committee on Energy and Natural Resources
Washington, DC 20510

Dear Senator McClure:

Attached are my written responses to the questions you asked in follow-up to my testimony before the Senate Committee on Energy and Natural Resources on June 19, 1986.

We appreciated the opportunity to testify before your Committee and look forward to providing an update on INPO activities in the future. If you have any questions regarding these responses or INPO programs and activities in general, please call me at (404) 980-3200 or Bill Conway, group vice president, Industry and Government Relations, at (404) 980-3207.

Respectfully,

Zack Pate

Zack T. Pate
President

ZTP:las
Attachment

## INPO RESPONSES TO QUESTIONS BY THE SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES

Question: INPO was established by the nuclear electric utility industry to promote improved performance, yet the utility industry provides financial support for INPO. How does INPO maintain its independence from a single utility or group of utilities, and from the NRC? What authority/clout does INPO have over member utilities?

Answer: INPO is able to maintain its independence from any single utility or group of utilities because each contributes but a portion of the funding total. Rather, INPO's member utilities have considerable financial dependence upon their INPO membership. INPO's need for authority among its members was anticipated by its Board of Directors which established provisions, up to and including loss of INPO membership, for failure of any utility to respond sufficiently to INPO initiatives. Such action would result in grave financial consequences for such a utility, including loss of insurance coverage from Nuclear Electric Insurance Limited (NEIL).

To assure INPO's independence from the NRC, a Memorandum of Agreement, with a number of supporting coordination plans, has been endorsed by both organizations. INPO and NRC conduct their respective activities under this Memorandum of Agreement and meet periodically to ensure that a clear understanding of this agreement is maintained.

Question: How does INPO assure that utility training programs that are accredited meet the high standards necessary to achieve safe and reliable operation of our nation's nuclear power plants? What is the federal involvement in the accreditation process?

Answer: Federal involvement in the accreditation process is assured by four of the twenty members of the National Nuclear Accrediting Board, who have been nominated to serve by the NRC. The Charter of the National Nuclear Accrediting Board requires participation by a federally nominated member each time an accrediting board is convened for action.

The NRC has the opportunity to observe all facets of the accreditation process including Accrediting Board meetings and INPO accreditation team site visits.

The INPO professional staff responsible for reviewing utility training programs has been carefully selected to include persons with a broad range of diverse backgrounds and records of high standards of personal performance. Accreditation criteria have been developed to ensure that accredited programs meet high standards for performance based training. INPO also evaluates accredited utility training programs as part of the normal plant evaluation process, and reaccreditation is required every four years.

Question: You have shown the Committee graphs that indicate overall industry performance appears to be improving and you have also discussed the long-term 1990 goals. Yet 1985 appeared to be one of the worst years yet for nuclear power with the Davis-Besse and Rancho Seco events and with the problems at TVA. How can you say that significant improvements have been made in light of the above problems? What did INPO do to prevent the above problems?

Answer: An important aspect of the TVA situation that is often overlooked is the following: TVA management took the action to shut down the Brown's Ferry plant and later the Sequoyah plant. TVA managers were certainly mindful of interactions with the NRC and input from INPO, but it was TVA management that took that initiative; and management action to shut down the plants is a far better situation for TVA, and for the industry, than continuing to operate until a serious event occurs. So in that sense, the management action at TVA was healthy.

In the case of Rancho Seco and Davis Besse, both the NRC and INPO had recognized developing potential problems, and from my own personal knowledge I can report that both organizations were working with the senior management of both utilities to bring about improvements in the way the plants were operated. In retrospect, we weren't early enough and perhaps we weren't aggressive enough.

In early Fall of 1985, INPO did take action to request that the Rancho Seco plant remain shut down until certain corrective actions were taken, and improvements or upgrades of certain operational activities were put in place before the plant started up some five weeks later.

We have strengthened our evaluation program as a result of lessons learned at TVA, Rancho Seco, and Davis-Besse, and will do everything we can to assist utilities and the government in heading off those kinds of problems in the future. Just as you do, we regret the situation faced by all three utilities involved.

Nevertheless, as indicated in my testimony, the overall industry record has been one of improving performance during recent years.

Question: INPO's mission is to promote the highest levels of safety and reliability -- to promote excellence -- in the operation of nuclear electric generating plants. How well qualified is the INPO staff to set and enforce standards of excellence?

Answer: INPO's strength is in its people. Over 135 individuals with utility experience are currently on INPO's staff. In addition, over 70 individuals who were officers in the Navy nuclear propulsion program are now employees of INPO.

Over 55 of our personnel have held licenses or certification as nuclear power plant senior reactor operators.

INPO's personnel selection process has been careful and thorough, and its employees are highly qualified to set and enforce standards of excellence.

Question: What actions has INPO taken or planned to take regarding its program in view of the accident at Chernobyl?

Answer: Subsequent to the accident, we provided information to our members via NUCLEAR NETWORK™, a computerized, electronic, international communications system typically utilized for the exchange of information among INPO members and participants.

On May 8, 1986, the Utility Nuclear Power Oversight Committee (UNPOC), a group of senior executives representing industry organizations formed a task force to assess the implications of the Chernobyl accident in order to determine a course of action for the industry. INPO is serving a significant role as a task force member with responsibility for ultimate development of "The Role of Operating Personnel" chapter of the U.S. Factual Report on Chernobyl.

Any lessons learned from our review of the Chernobyl event will be integrated into ongoing INPO programs.

Question: How can this Committee be of help to INPO in carrying out its mission?

Answer: We request the Committee's encouragement and endorsement of the INPO-managed efforts as described in my testimony and as outlined in the documents furnished with the testimony. Further, we would appreciate having the opportunity to periodically update this committee, and through this committee the full Congress, on INPO activities and the operating performance of the nuclear utility industry.

Question: With all your evaluations of everything from training to corporate management, you should be well equipped to be able to discover an accident waiting to happen. Have you ever had such an occasion? Have you succeeded in getting the particular problem resolved? Do you communicate directly with the NRC on the problems you uncover in your reviews?

Answer: In today's environment, strict design controls and rigorous technical specification requirements (established by the NRC) provide safeguards so that plants are unlikely to fall into a physical condition where an accident is "waiting to happen." The greatest likelihood for a serious nuclear event resides rather in the human side of the plant performance equation, namely through personnel error. In order to minimize this likelihood, INPO has focused on improved training and performance of nuclear power plant personnel through both the accreditation and evaluation processes. These processes examine the content and implementation of nuclear plant training programs, the level of knowledge of nuclear plant personnel, and the actual performance of workers in their day-to-day activities.

NRC has access to the results of INPO's evaluations. In the event that INPO identifies a serious situation at a nuclear power plant, it has established procedures for informing the NRC in accordance with 10 CFR 21.

Question: The Soviet Union is not now a member of your International Participation Program. What is the likelihood that the Soviet Union will join INPO so as to be able to directly share with other INPO members its operating experience, especially the "lessons learned" from the Chernobyl accident?

Answer: In close cooperation with DOE, NRC, the International Atomic Energy Agency, and INPO's International Participant Advisory Committee, INPO is investigating the possibility of expanding its international program. INPO would be pleased to provide updates on this effort to the Committee on Energy and Natural Resources as the effort progresses.

Question: Please comment on the news article that Senator Bumpers referred to that states that 1985 was the worst year since Three Mile Island, in terms of the nuclear industry's safety record.

Answer: INPO agrees that 1985 was not a good performance year for some individual utilities operating nuclear facilities (i.e. Sacramento Municipal Utility District, Toledo Edison, TVA). However, the significant actions currently being taken by these utilities to upgrade overall performance are not reflections of a lessening of regulatory activity.

Additionally, while certain events last year received considerable public attention, the fact is that the number of significant events per operating nuclear power unit as adjudged by INPO has declined over 67 percent since 1981. This decline is indicative of a rising threshold of overall nuclear power plant performance since the criteria used by INPO to analyze and classify events have remained essentially constant. This information is covered more specifically in the written testimony and the June 1986 performance indicator brochure attached to the testimony.

GA Technologies

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SENATE COMMITTEE ON
ENERGY AND NATURAL RESOURCES
RECEIVED
JUL 7 1986
WASHINGTON, D.C. 20510

July 2, 1986

The Honorable James A. McClure
Chairman
Committee on Energy and Natural Resources
U. S. Senate
Washington, DC 20510

Dear Senator McClure:

The enclosed material is respectfully submitted in response to your request of June 25, 1986. I appreciated the opportunity to appear before your Committee and am pleased to have this information made part of the hearing record.

Sincerely yours,

R. A. Dean
Senior Vice President
Reactor Programs

Enclosure

10955 JOHN JAY HOPKINS DR. SAN DIEGO, CALIFORNIA 92121

Question 1.

From what I understand, a Modular High Temperature Gas Reactor (MHTGR) contains neither zirconium fuel cladding nor water -- two of the major "players" that resulted in the formation of hydrogen and the subsequent hydrogen explosion that caused the sudden, massive release of radioactivity into the atmosphere at Chernobyl. So this kind of accident scenario is virtually impossible for an MHTGR. Am I correct?

Answer

Your understanding is correct. The Modular High Temperature Gas-Cooled Reactor (MHTGR) uses inert helium gas as a coolant so that no reaction or explosion can take place between the coolant and the fuel, fuel coating, or structural materials in the reactor system. Further, no zirconium is present in the system so that even in the rare circumstance where water would enter, no metal/water reaction would take place to result in the formation of hydrogen with a subsequent explosion. Although water may, under certain circumstances, react with the graphite in the core, the reaction is endothermic (absorbs heat) and therefore self-limiting so that the Chernobyl type scenario is virtually impossible.

Question 2.

Is there interest on the part of the utilities in buying an MHTGR, if they prove to perform as promised?

Answer

Historically, the electric utilities have supported the HTCR program since 1978 through Gas-Cooled Reactor Associates (GCRA), a utility user supported and managed organization. This group represents about a third of the nation's generating capacity. The specific design features of the MHTGR have been determined to meet performance, safety, and investment requirements established specifically by the GCRA utilities. Further, these utilities are currently leading development of a Project Plan, which calls for a significant investment from the private sector - primarily the utilities themselves, that would lead to the demonstration of the MHTGR concept and to its licensing certification for replication. These activities are based on the conviction that the concept when demonstrated will provide an advanced, second-generation nuclear plant for installation by utilities domestically, as well as outside of the United States.

Question 3.

Are DOE and EPRI participating with you and others in the development and prototype testing of the MHTGR reactor design? Please elaborate. What kind of funding would it take to fully design, build and test an MHTGR?

Answer

There is wide participation in the design, development, and programmatic activities of the MHTGR reactor. The U.S. Department of Energy, in addition to providing overall program management and support, participates directly in the technical activities through Oak Ridge National Laboratory (ORNL) and Idaho National Engineering Laboratory (INEL). ORNL has been designated as the lead organization for the MHTGR technology development efforts. INEL provides overall top level guidance to the program and participates in design review. The INEL site has also been recommended by the program participants as a prime candidate for an MHTGR demonstration plant.

As indicated in the answer to question 2., the utility industry is active in the MHTGR program. EPRI participation is through Gas-Cooled Reactor Associates (GCRA). Although limited by funding, their participation includes representation on the GCRA Board of Directors and participation in the various management and technical committee activities. In addition, EPRI has redirected the scope of a number of their ongoing development programs to provide results which contribute to the MHTGR program.

The level of funding required to fully design, build, and test an MHTGR is currently being developed as part of a Project Definition Study. This study, which is supported by the utility, vendor, and architect-engineer participants in the MHTGR program, is being carried out under the direction of GCRA. In addition to determining overall costs, the study will define project requirements and scope, benefits, and limitation and recommend the basis for the sharing between private sector and government support of the project. Preliminary indications, with major input from Bechtel and Stone & Webster, are that the total cost to perform the design, development, and construction, and to operate a full scale 135 MWe Modular HTGR power station in a demonstration mode for several years is about $800 million.

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